DECEMBER 1980

NATIONAL AVIATION SYSTEM DEVELOPMENT AND CAPITAL NEEDS

For the Decade

1982 - 1991

US. Department of Transportation
Federal Aviation Administration

NOTICE

This document is for planning purposes only, and does not represent a *commitment by the Executive Branch*.

U.S. DEPARTMENT OF TRANSPORTATION
FEDERAL AVIATION ADMINISTRATION
Office of Aviation Policy and Plans
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EXECUTIVE SUMMARY

The National Air Transportation System is facing a challenging decade of rapid growth. Even if general, national economic expansion is only modest, by 1991 civil aircraft activity will increase by over 40 percent, air carrier enplanements by over 50 percent, and commuter airline enplanements by 170 percent. To put this growth in perspective, aircraft operations will increase roughly one and one-half times as much in the coming decade as they did in the decade just ending. Investment in the air traffic control and air navigation systems, in supporting Research and Development programs, and in airport development, must keep pace with growth or system performance will suffer in terms of safety, capacity and productivity.

The excellent safety and operational record of the National Aviation System masks the fact that investment in Federal Aviation Administration (FAA) Facilities and Equipment (F&E), particularly when compared to other transportation modes, has suffered through a ten-year period of decline. While actual dollar levels have remained relatively constant, the impact of inflation has reduced the purchasing power of these dollars to barely a third of FY 1972 levels. This decline in real capital investment has left the FAA with an aging inventory of equipment, requiring ever higher levels of maintenance and continually increasing costs.

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$450 million to $8.5 billion in 1980 dollars. This latter figure, $8.5 billion (which is more than $14 billion in current dollars. given the expected rate of inflation) is determined to be the minimum F&E investment needed to prevent serious deterioration. Using somewhat less elaborate methodology, the other investments needed to prevent this deterioration have also been defined: $1.6 billion in supporting Research and Development Programs, and $6 billion in airport development. This total Federal investment is essential, but must be complemented by other operational improvements to be fully effective. For example, the $8.5 billion F&E investment will satisfy 20 percent of the safety needs, 5 percent of the capacity needs and 13 percent of the productivity needs leaving significant challenges for FAA's developmental, regulatory and airports programs. FAA recognizes that it must continue to improve its regulatory and management techniques. Nevertheless, without a significant modernization of the physical plant, such efforts ultimately will fall short.

With the installation of major automation improvements and investments in more efficient facilities and equipment, FAA productivity will rise. Personnel requirements will increase about one percent during a decade of unparalled system growth. Some $30 billion in 1980 dollars will be needed to fund operations and staffing during the period 1982-1991.

The difficulty of the airport capacity question should by no means be underestimated. These capacity problems will be costly. Delay costs in 1980 dollars, which exceeded $500 million in 1979 at the major 24 hub airports, will reach $1.5 billion by 1986 and $8.0 billion by 1991. A 1977 FAA study estimated that as many as 19 major new air carrier

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B. AVIATION GROWTH. According to official agency forecasts, the FAA-managed National Air Transportation System will experience rapid growth during the next decade. Marked increases in user demand for FAA services are predicted even when one assumes moderate economic growth, rising energy prices, and erosion of consumer purchasing power brought about by continuing inflation. As shown in Figure I-l, by 1991 user demand for terminal services is forecast to increase 40 percent, IFR en route services by 45 percent, and flight service station services by 51 percent over 1979 levels. Among the various classes of users, air taxi growth spurred by commuters1/ is largest, followed by general aviation and air carriers. Activity growth at major airports, although at a rate below national average, is expected to be about 26 percent. The low

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FIGURE I-2
Forecast Growth In Enplanements
1979 to 1991
(Percent)

	Total	Large Terminals (24 Major Airports)
Air Carriers	61.2	48.8
Commuters	170.2	144.6

Source : FAA Aviation Forecasts: Fiscal Years 1981-1992, and Terminal Area Forecasts, November 1980

C. DEVELOPMENT AND CAPITAL NEEDS. It is difficult to identify the future capital needs of the National Airspace System in an environment of severely changing costs. One problem encountered in formulating a long-range estimate has been that of accurately defining system performance generated by various levels of funding and staffing. System performance benefits expected from alternative levels of capital investment have not been accurately defined. Nor, for that matter, has the point where system saturation with minimum capital funding and essentially constant staffing been defined.

This study attempts to correct those shortcomings and to estimate the capital and staffing needs necessary to handle forecasted growth during the 1982-1991 decade. With respect to Facilities and Equipment (F&E) investments, five investment strategies for the air traffic control and air navigation systems have been formulated. Using existing, rough and very conservative estimates, benefits have been calculated for each strategy in terms of safety, capacity and productivity, measured by dollars, lives saved and hours of delay prevented. While the details of

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D. SYSTEM PERFORMANCE. System performance is best measured in terms of safety, capacity and productivity. Performance in all three areas clearly reflects the capital investments made in air traffic control and air navigation facilities, and in airport improvements. For example, the accident records for both air carrier and general aviation have improved markedly over the past decade, partly because of previous investments in new and improved navigation, communication and radar facilities, investments in airport development, and technological and regulatory improvements by the FAA and industry. However, the utility of those investments will be stressed by projected growth to the point where system performance will suffer. It is estimated that if no new investments are made, the annual accident costs will increase from an average of $927 million in 1979, to an annual average of $1,222 million during 1982-1986, and $1,433 million during 1987-1991.

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Chapter IV presents a basic outline of FAA programs and is followed by a glossary of abbreviations.

Appendix I contains an outline of the specific programs described in Chapters III and IV. Minor adjustments in the timing of a few of these programs have been made since completion of the Chapter III analysis. With this exception, the programs are consistent with those included in Chapter III.

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To describe its functions, the ATC system can be divided into three categories: En Route, Terminal and Flight Services.

a. En Route. En route services are provided in the airspace over the continental United States from 20 FAA facilities known as Air Route Traffic Control Centers (ARTCC's) . Two other ARTCC's provide en route air traffic control services in Alaska and Hawaii. Combined Center/Radar Approach Control (CERAP) facilities on Guam and San Juan, Puerto Rico, provide en route Air Traffic Control (ATC) services in those areas.

The radar surveillance data required to provide these services are derived from 104 long-range Air Route Surveillance Radars (ARSR's) and 11 secondary radar sites (Beacon only sites) . En route remote center air-ground (RCAG) communications are provided by about 500 installations. Ground to ground and internal communication capabilities are mainly provided with leased equipment and systems.

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Terminal Control Area (TCA) - Controlled airspace extending upward from the surface to specified altitudes, within which all aircraft are subject to specific operating rules and pilot and equipment requirements. The specific operating requirements in a TCA are specified in FAR Part 91. As of October 1, 1980, 22 TCA's were in operation.

Other FAA owned and maintained terminal facilities consist of electronic and visual terminal aids to provide accurate approach and landing guidance. These systems include 621 commissioned precision Instrument Landing Systems (ILS's) at 430 airports as of August 31, 1980, that provide both horizontal and vertical electronic guidance during varied visibility conditions without compromising safety. In addition there are 829 Visual Approach Slope Indicators (VASI's) to visually provide the pilot glide slope information which is provided electronically by the ILS, and 577 approach lighting systems to assist pilots during low level visibility conditions as well as taxiway and runway lighting systems used during all weather conditions.

c. Flight Services. Three hundred and nineteen (319) Flight Service Stations provide weather and aeronautical information services primarily to general aviation pilots. These services include: flight plan processing, preflight and inflight weather briefings, en route communications, and emergency services such as assistance to lost aircraft.

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IFR Aircraft Handled By User Category
(Millions)

	FY-1975	FY-1979	Ave. Ann. % Change	Estimate FY-1980	FY 75-80 % Change
Air Carrier	12.4	14.0	3.1	13.9	12.1
Air Taxi	1.3	2.3	15.3	2.5	92.3
General Aviation	5.5	8.8	12.5	9.0	63.6
Military	4.4	4.8	2.2	4.7	6.8

Source : FAA Aviation Forecasts, Fiscal Years 1981-1992

Percent of Total Aircraft Handled By User Category

	FY-1975	FY-1979	Estimate FY-1980
Air Carrier	52.5	46.8	46.2
Air Taxi	5.6	7.8	8.3
General Aviation	23.4	29.5	29.9
Military	18.5	15.9	15.6

Source: FAA Aviation Forecasts, Fiscal Years 1981-1992

b. Terminals. The mix of major tower cab workload has changed little in recent years; about 75 percent for general aviation and 15 percent for air carrier. However, the air taxi share has increased rapidly while the military share has declined. The IFR room workload has been changing dramatically along the same lines as the center workload, with high rates of increase for air taxi and general aviation.

Aircraft Operations By User Category
(Millions)

	FY-1975	FY-1979	Ave. Ann. % Change	Estimate FY-1980	FY 75-80 % Change
Air Carrier	9.4	10.4	2.6	10.3	9.6
Air Taxi	2.7	4.4	13.0	4.7	74.1
General Aviation	44.2	51.7	4.0	51.1	15.6
Military	2.7	2.5	-1.9	2.5	-7.4

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Percent of Total By User Category

	FY-1975	FY-1979	Estimate FY-1980
Air Carrier	4.8	5.0	4.7
Air Taxi	8.3	10.2	10.4
General Aviation	80.0	80.5	80.2
Military	6.9	4.3	4.7

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(3) Geographical Distribution of Workload

a. En Route. Although aircraft activity varies geographically throughout the conterminous United States, centers have been located and configured in a manner which provides a relatively uniform distribution of workload. In 1979 the six centers which serve the area which used to be called the Golden Triangle (the area bounded by lines drawn from Chicago to Boston to Washington, D.C. to Chicago) handled about 35 percent of the workload, compared to the forecast of about 30 percent (6 of 20 centers). Military activity is heavily concentrated in the Sun Belt.

b. Terminals. The heaviest concentration of tower cab activity is in California. The FAA Western Region alone, which comprises the States of California, Nevada and Arizona, has over 21 percent of the total. The IFR room activity, however, mirrors that of the en route centers. The three regions included in the Golden Triangle (New England, Eastern and Great Lakes) collectively experienced about 36 percent of the total FY-1979 activity.

c. Flight Services. Flight Service Station (FSS) activity is also distributed relatively evenly throughout the nation, except that Alaska has a much higher percentage of FSS activity than it does in the

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Figure II-2

GENERAL AVIATION ACCIDENT HISTORY *
(ACCIDENT RATES PER 100,000 AIRCRAFT-HOURS FLOWN)

‘INCLUDES FATAL AND NONFATAL ACCIDENTS.

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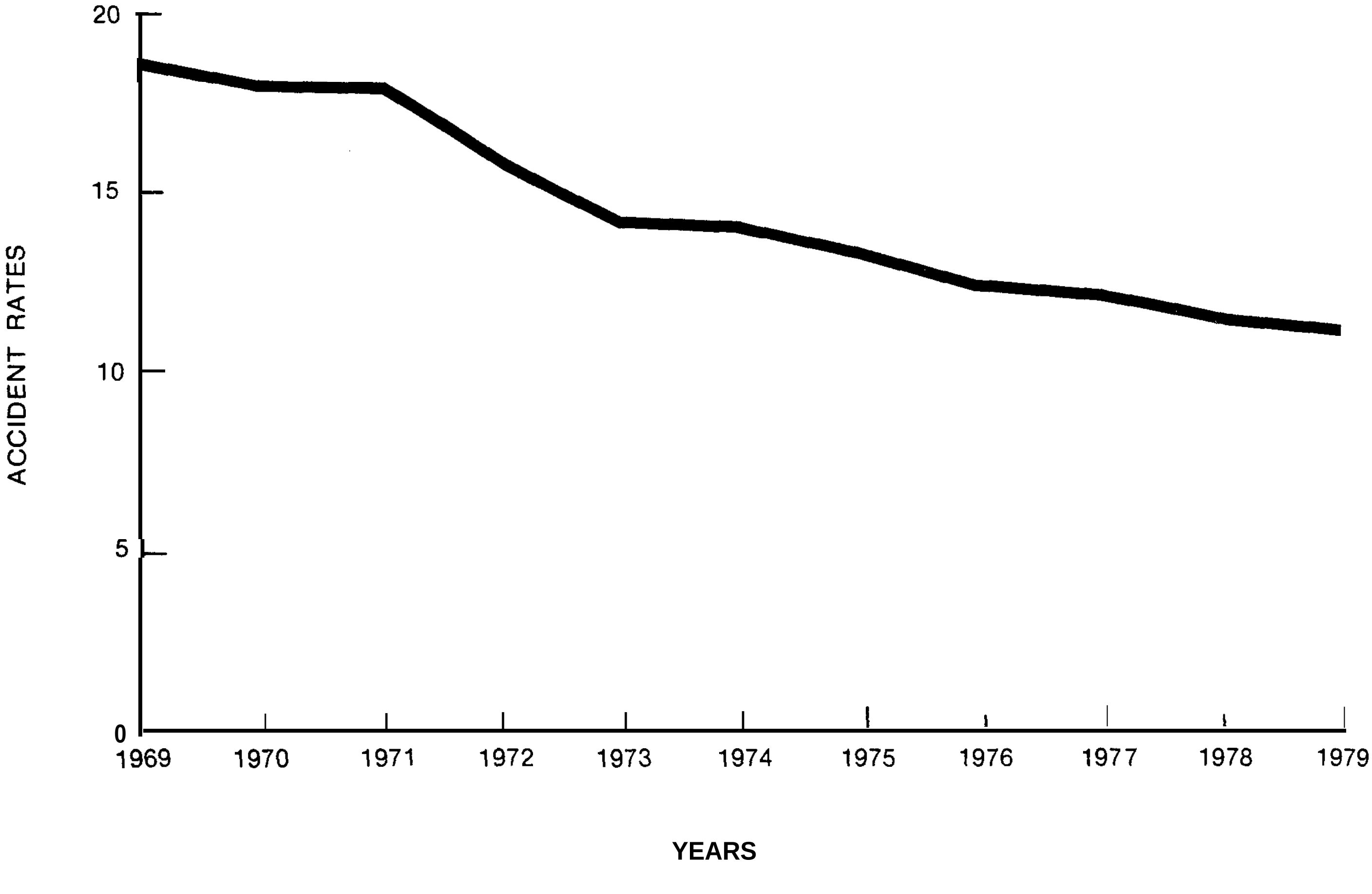

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These costs are based on estimated delays at the twenty-four major airports analyzed in a 1977 FAA study. 1/ They have been updated to reflect current forecasts of operations and enplanements and include an assumption that air carriers will not, on their own accord, restrict demand at congested airports. These delays are shown in Figure II-5. The 1979 estimate of $572 million (1980 dollars) represents the system baseline for capacity. Baseline capacity is the level of performance achieved by the system as it exists today, with its related complement of facilities, sensitivities to weather, and existing congestion problems. The 1982 to 1986, and 1987 to 1991 estimates, which average $1.9 billion and $8.0 billion respectively on an annual basis, represent lower bounds of actual delay costs that would be incurred if no capital investments were made and no other effective measures were taken to reduce delays. There are certain qualifications about these costs. First, these costs are based on estimated delays at only 24 airports (approximately one half of system delay is generated at these airports). Second, general aviation costs are excluded. Partially offsetting these factors, however, is the prospect that rising delays and costs would probably cause the airlines to adjust their schedule so as to reduce delays. Nevertheless, although measured delay might be thus reduced, real economic costs might not go down because such airline rescheduling would result in a less than desired use of the flying public's time.

1/ "Establishment of Major Public Airports In The United States" August 1977

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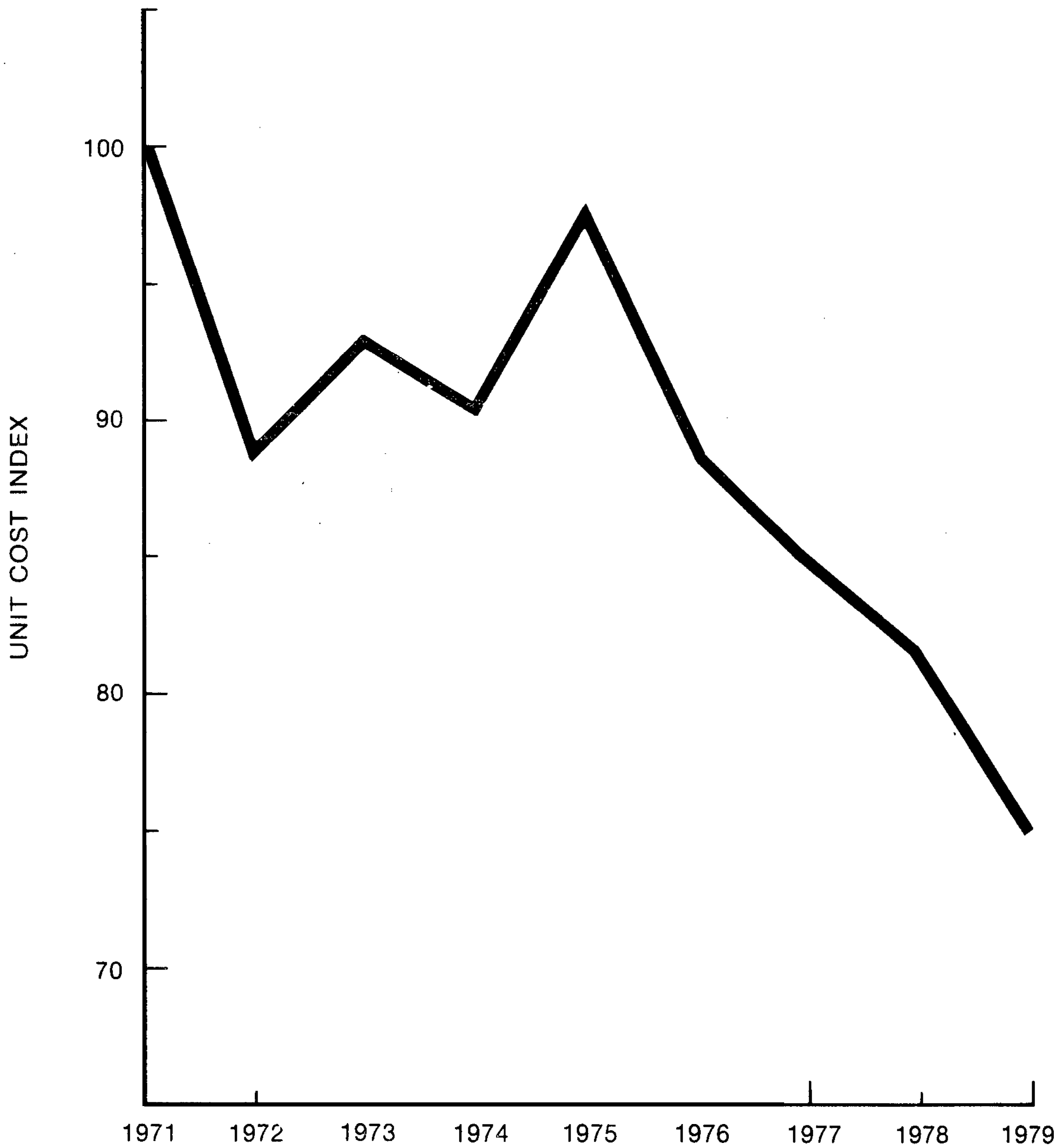
1/ "Establishment of Major Public Airports In The United States" August 1977

FIGURE II-6

PRODUCTIVITY INDEX
MEASURE OF FAA COST PER UNIT OF OUTPUT
(1971 100)

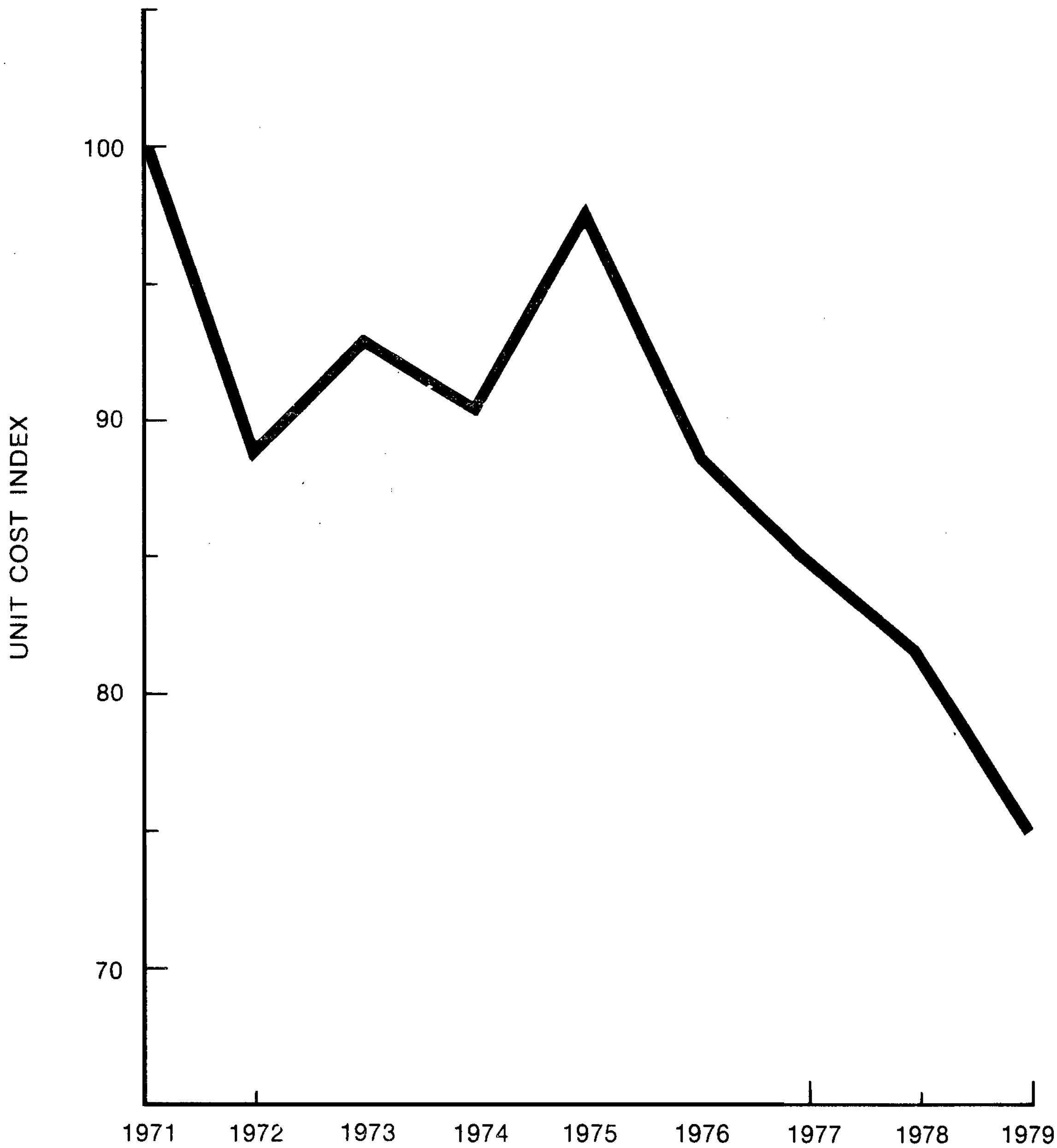


FISCALYEAR

NOTE: CONSTANT DOLLARS

FIGURE II-6

PRODUCTIVITY INDEX
MEASURE OF FAA COST PER UNIT OF OUTPUT
(1971 = 100)

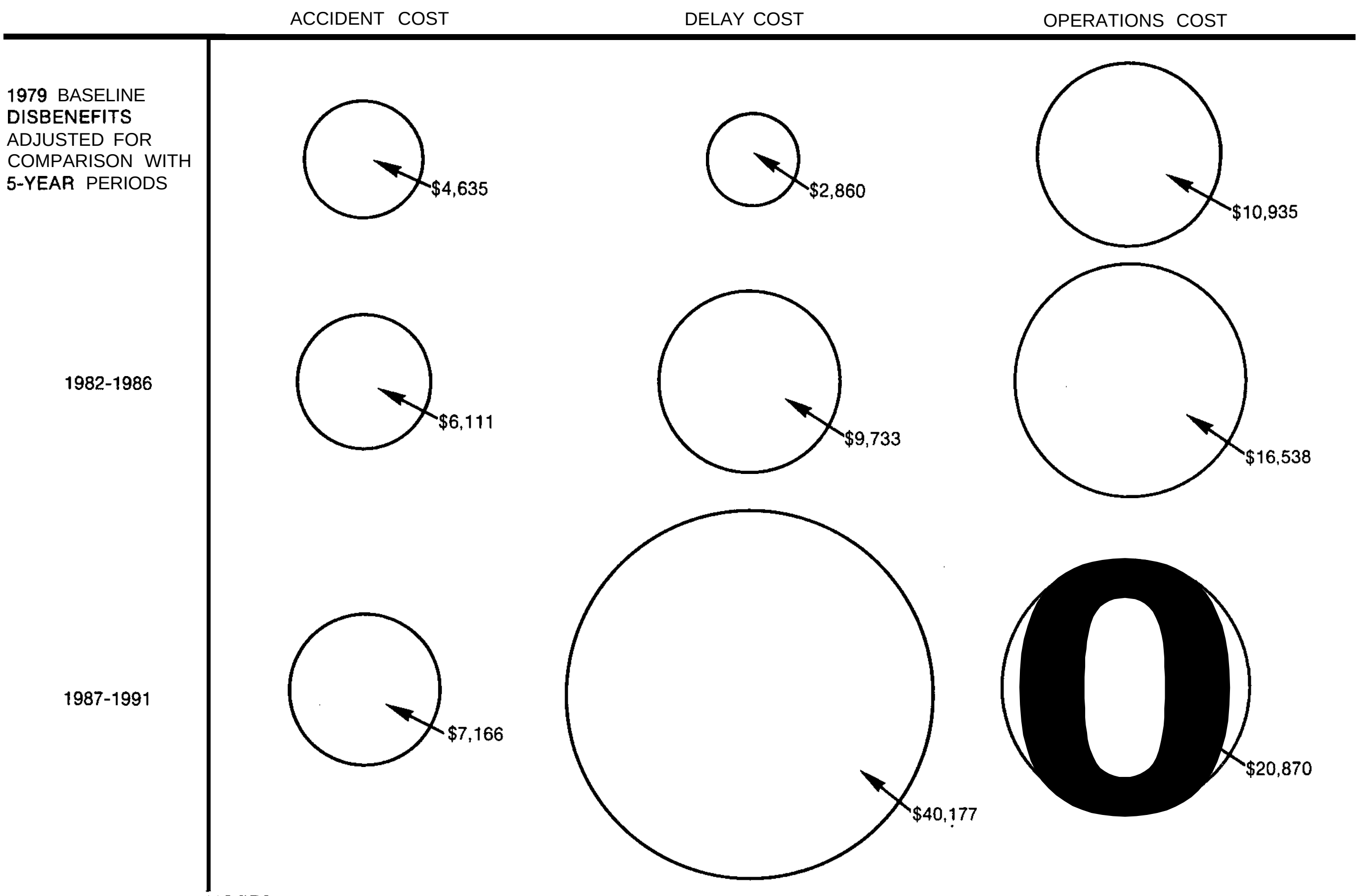


FISCALYEAR

NOTE: CONSTANT DOLLARS

FIGURE II-8

INDICATORS OF SYSTEM PERFORMANCE ASSUMING NO CAPITAL EXPENDITURES



NOTES:

1. IN MILLIONS OF CONSTANT 1980 $'s.
2. THE CIRCLES REPRESENT THE DOLLAR DISBENEFITS ACCRUED IF NO CAPITAL INVESTMENTS ARE MADE FOR EXPANDED, NEW OR MODERNIZED FACILITIES.

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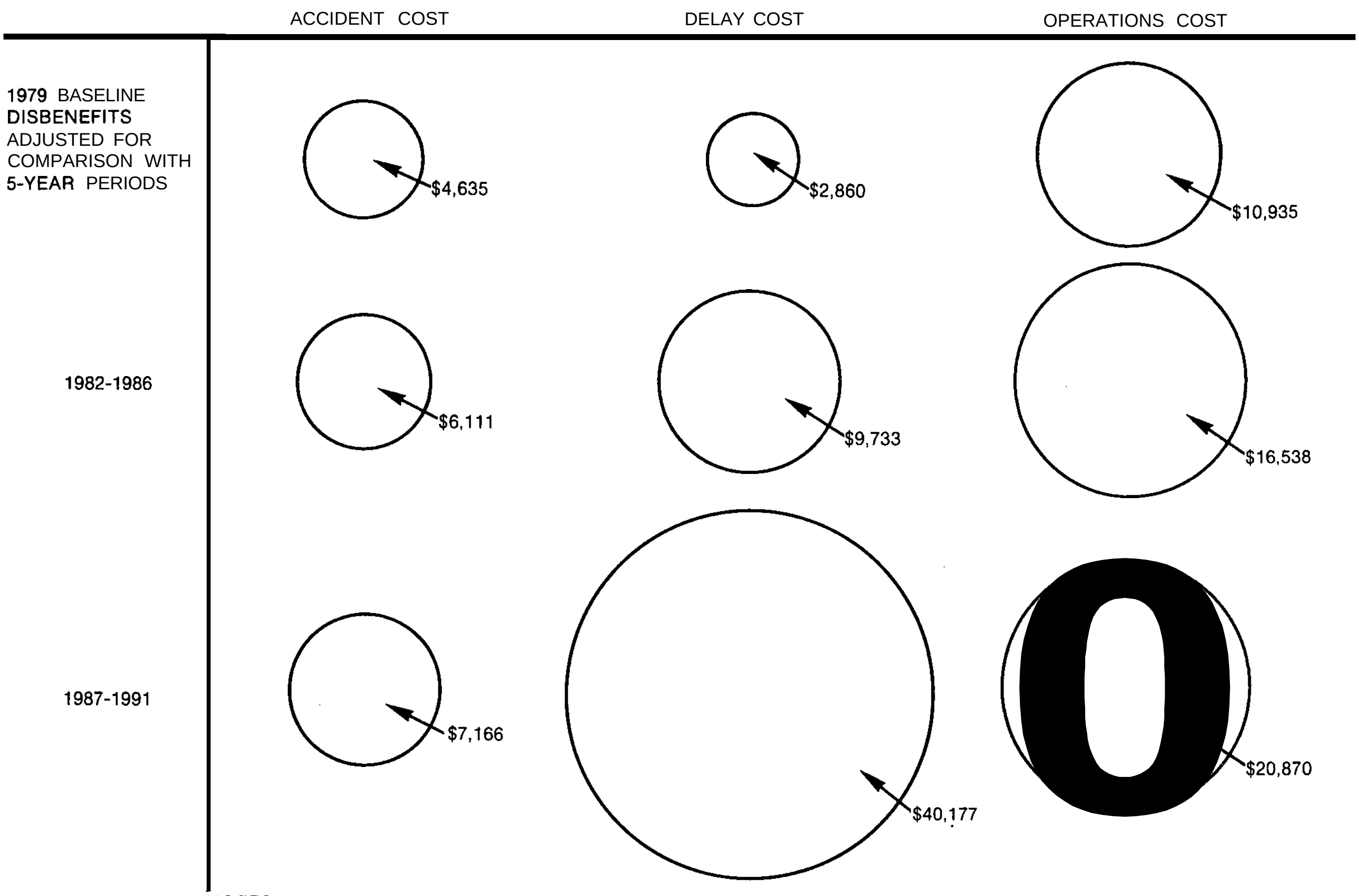

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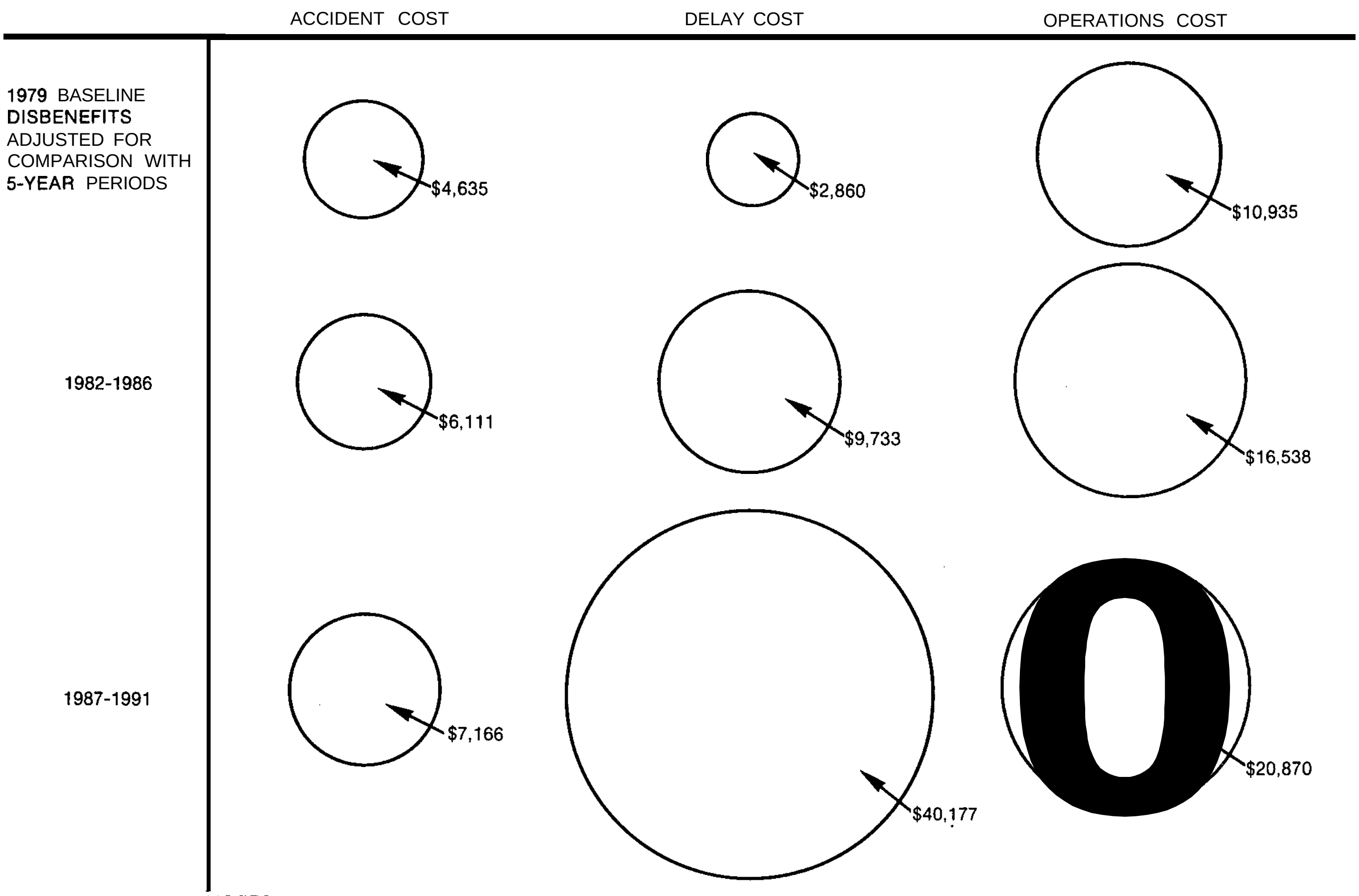

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operations are expected to increase by only 21 percent during the same period, reflecting a continuing trend to aircraft with greater seating capacity, higher load factors, and longer average stage lengths.

In 1980, the commuter carriers will carry 13.8 million passengers, or 4.5 percent of all fare paying passengers in scheduled air service. By 1992, these carriers are expected to carry 35 million passengers and account for 6.8 percent of all passenger enplanements as shown in Figure II-9.

Nationally, commuter aircraft operations are expected to more than double the 1980 estimated volume of 4.4 million operations by 1992. As air carriers restructure their routes, commuter airlines will continue to move into available markets in smaller cities, and they will perform more operations with smaller aircraft than those used by the trunk and local service airlines. In addition, they are expected to develop new markets as they have done in the past.

The Deregulation Act, for the first time, included the commuters in the Aircraft Loan Guarantee Program administered by the FAA. Aircraft purchases by these relatively small carriers along with opportunities created by the Act have led to a major expansion in the service provided by the commuters. The expansion is expected to continue through the 1980 recession. Future growth will moderate somewhat as this segment develops a mature route structure. Thus, while the number of revenue passengers increased 20 percent in 1979 over 1978 to 12.1 million, the average annual growth rate between 1980 and 1992 is expected to be 8.1 percent.

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FIGURE II-10

AVIATION ACTIVITY FORECASTS
(FISCAL YEARS)

AVIATION ACTIVITY	HISTORICAL 1975	1979	EST. 1980	FORECAST 1981	1982	1992	PERCENT AVG. ANNUAL GROWTH 75/79	79/80	80/81	81/82	80/92
AIR CARRIER, DOMESTIC											
REV. PASS. ENPS. (MILLIONS)	184.9	291.7	290.5	308.9	331.8	481.1	12.1	—0.4	6.3	7.4	4.3
REV.' PASS. MILES (BILLIONS)	127.7	205.6	201.9	215.9	232.9	352.7	12.6	—1.8	6.9	7.9	4.8
COMMUTER CARRIERS											
REV. PASS. ENPS. (MILLIONS)	6.6	12.1	13.8	15.5	17.2	35.0	16.4	14.0	12.3	11.0	8.1
REV. PASS. MILES (BILLIONS)	0.7	1.4	1.7	1.9	2.1	4.4	18.9	21.4	11.8	10.5	8.2
GENERAL AVIATION											
FLEET (THOUSANDS)	161.0	198.8	208.0	218.7	228.5	315.5	5.4	4.6	5.1	4.5	3.5
HOURS FLOWN (MILLIONS)	31.9	41.1	42.1	43.9	46.1	64.3	6.5	2.4	4.3	5.0	3.6

SOURCE: CAB, FAA DATA. FAA FORECASTS.

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and general aviation. Instrument flight rule departures and arrivals by the commuters are projected to more than double in the next 12 years.

Use of the growing capability of general aviation aircraft joining the fleet now and in the next 12 years is expected to increase the workload at the Flight Service Stations. General aviation business flyers, in particular, are expected to increase their utilization of Flight Service Station assistance to promote safe flying while meeting their schedules. The workload trends are shown in Figure II-13.

In summary, aviation activity is expected to continue to grow significantly faster than the general economy. Aviation will continue to dominate the commercial intercity passenger market. Commuter operations and business use of general aviation are expected to experience greater growth than the larger airlines and personal use of general aviation.

(3) Assumptions In FAA Workload Forecasts. Growth in FAA workload measures is a function of demand imposed on the National Airspace System plus inclusion of activity at locations previously not covered. That is the number of aircraft operations at FAA ATCT equipped airports in 1992 will consist of traffic at the towers existing in 1980 plus the traffic at the additional airports expected to have staffed FAA ATCT's by 1992. Most of the expected growth between now and 1992 will be experienced at the currently staffed FAA ATCT's.

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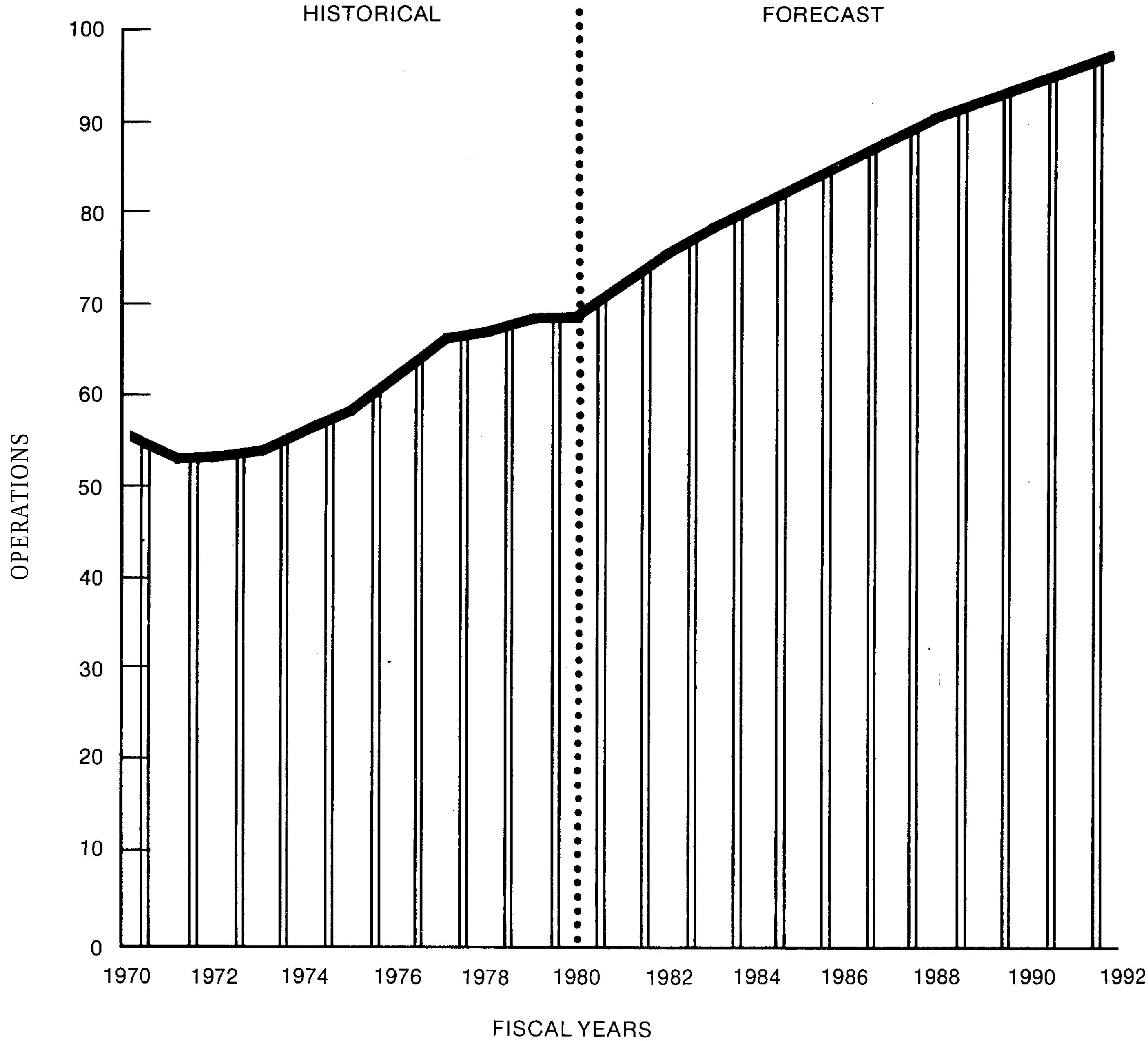
FIGURE II-14

TOTAL OPERATIONS AT AIRPORTS WITH FAA TRAFFIC CONTROL SERVICE (MILLIONS)



SOURCE: FAA AIR TRAFFIC ACTIVITY

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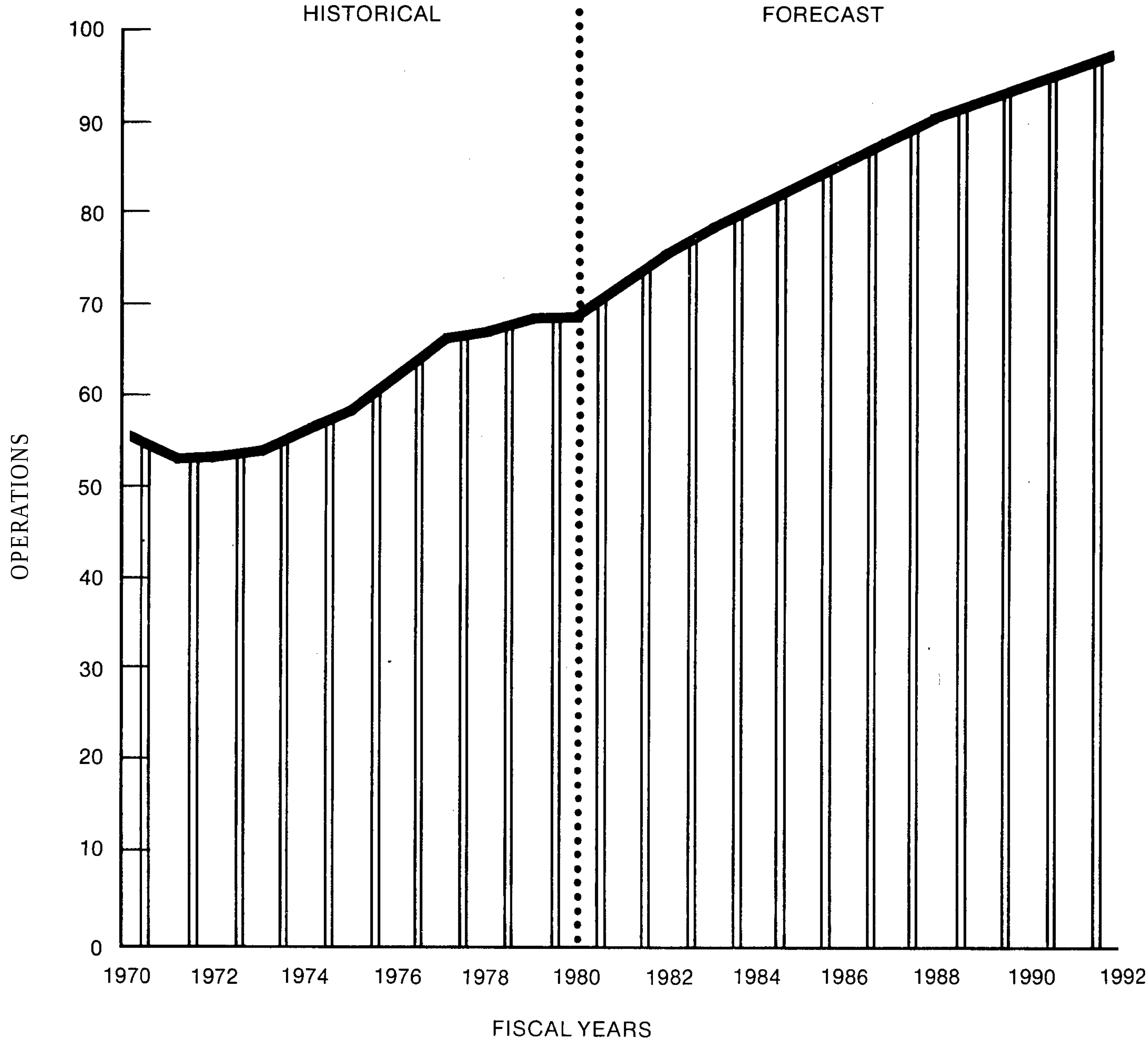
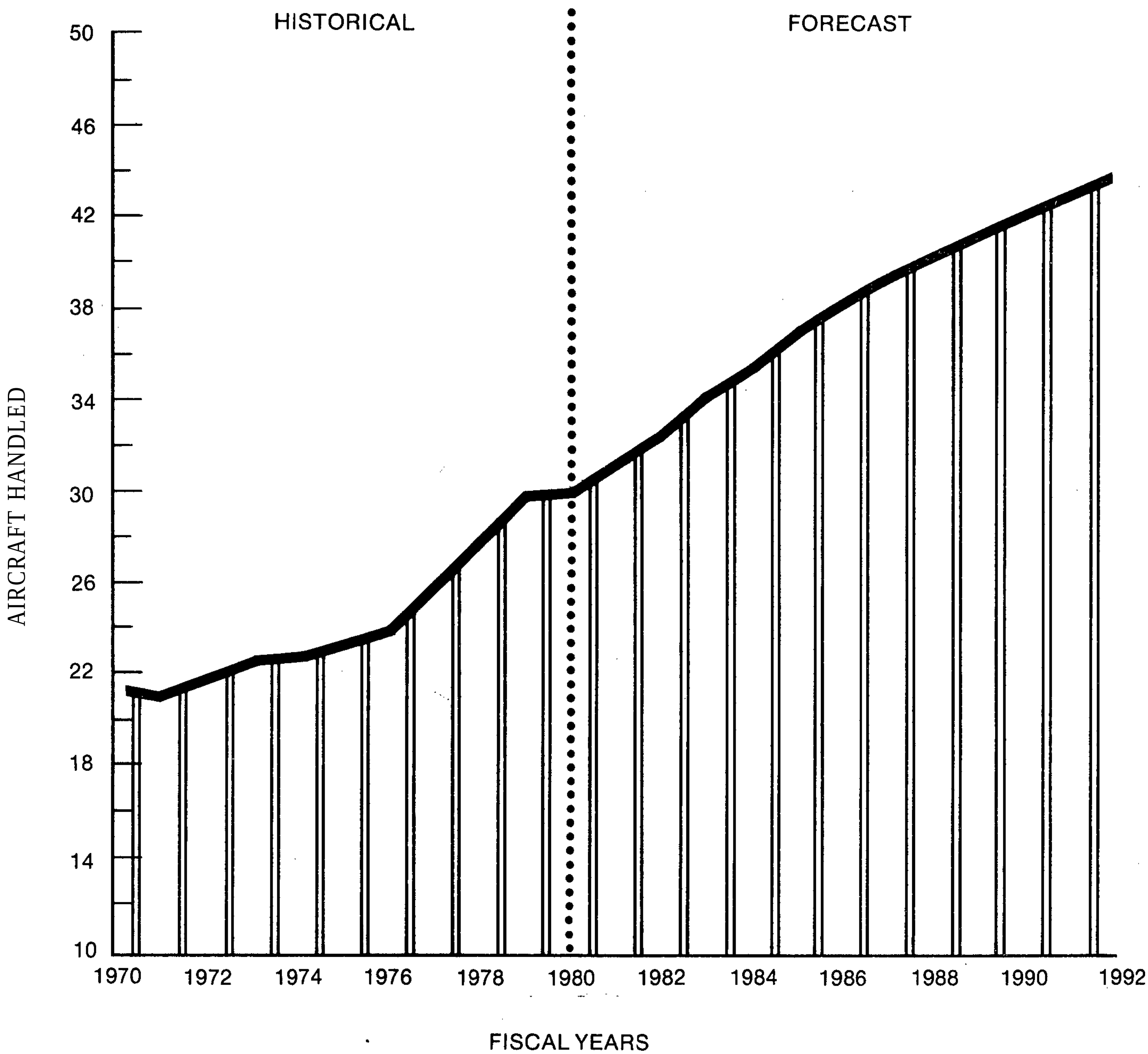


SOURCE: FAA AIR TRAFFIC ACTIVITY

FIGURE II-15

IFR AIRCRAFT HANDLED
(MILLIONS)



SOURCE: FAA AIR TRAFFIC ACTIVITY

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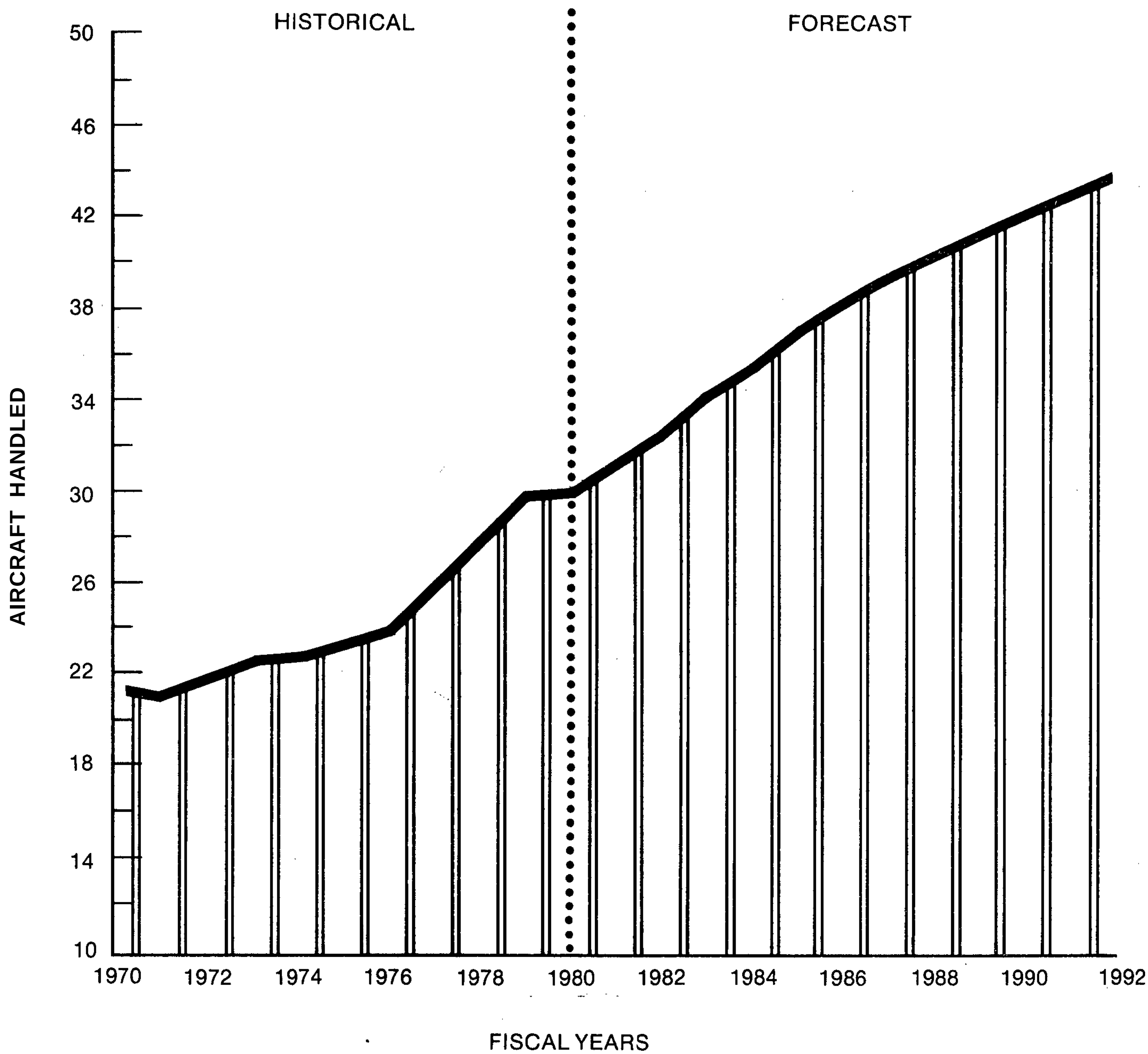
IFR AIRCRAFT HANDLED
(MILLIONS)



SOURCE: FAA AIR TRAFFIC ACTIVITY

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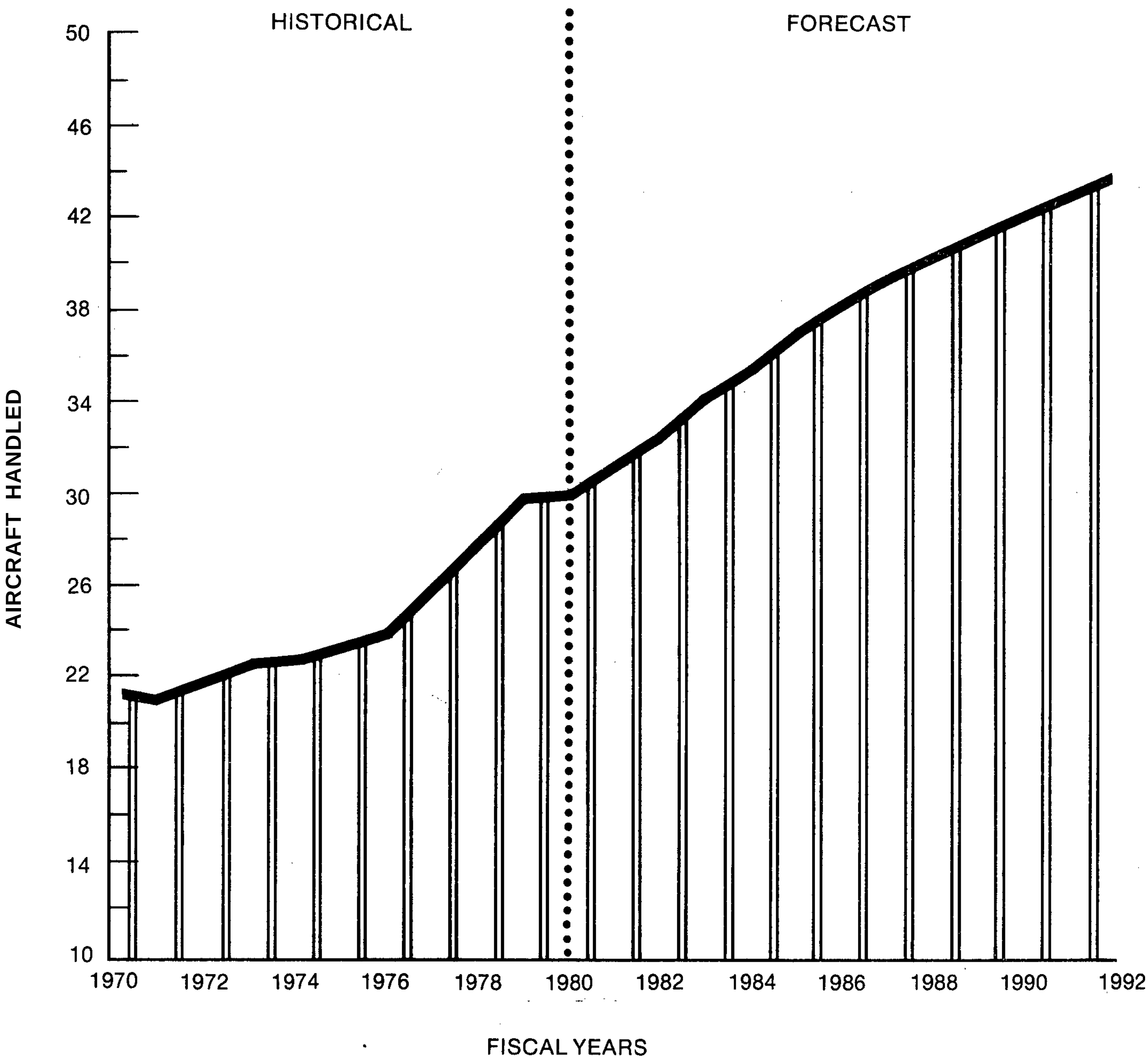

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addition to voice communications. An additional safety feature possible with the DABS is the automatic Air Traffic Advisory and Resolution System (ATARS). ATARS is a ground based (resident in the DABS computer) conflict alerting system that will automatically alert the pilot of potentially dangerous encroachments by other aircraft into his protected airspace and provide advisories as to maneuvers for resolving potential conflicts.

The terminal enhancements for this time frame include the Terminal Information Display System (TIDS), which will consolidate all data presently required by a tower controller in a more efficient and productive manner, and additional capabilities added to lower activity automated terminals (ARTS II) such as radar tracking and Minimum Safe Altitude Warning (MSAW). Microwave landing systems will begin to be deployed providing more fuel efficient and variable landing approach paths to airports. The MLS will be especially beneficial to reliever airports where terrain would not allow implementation of an instrument landing system. New solid state terminal radars (ASR-9) with moving target detection (MTD) and remote maintenance monitoring (RMM) will replace existing ASR-4, 5 and 6 tube type radars.

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The capital investment, as used here for all the DOT Administrations, includes programs that yield future benefits through construction, acquisition or alteration of physical assets.

An index indicating change in constant dollars of the FAA capital expenditure Facilities and Equipment appropriations as compared to the other DOT modes is shown in Figure III-l. Although these appropriations cannot be taken as complete and absolute measures of capital investment, they are nevertheless indicators of the general trend in the Federal share of major capital investment activity over the last decade. The inability to account precisely for capital investment activity arises because capital budgets are not identified specifically as "capital or investment-type programs" financed separately from "current or operating-type programs;" rather, DOT budgets are typically program-oriented. However, the comparison illustrates the relative long-term trend in the Federal share of capital investment in transportation and dramatically shows that FAA has consistently done most poorly in receiving capital expense appropriations when compared to the other DOT Administrations.

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(2) Levels of Funding.

a. Airport Grants-In-Aid Program. The current status of the Airport Grants-In-Aid Program reflects actions that were taken in the late 1960's. At that time, airport congestion was an extremely serious problem that was expected to worsen rapidly as air traffic increased. Relatively few major improvements had been made to the civil airport system since the end of World War II, when many military facilities had been converted to civil use. A major investment was needed to increase the capacity of busy air carrier airports, upgrade airports to serve jet aircraft, and provide new and improved general aviation airports. The ability of the aviation community to finance development on this scale was severely limited, because only the busiest airports generated enough revenues to be self-supporting. There had been the modest Federal Aid Airport Program (FAAP), funded out of general revenues, but it never exceeded $75 million annually, and this was too little to finance effectively the development that was needed.

After lengthy deliberation, a trust fund was established by the Congress in 1970 to provide some of the necessary financing. The fund received revenues from a variety of user taxes and fees, the most significant of which was an eight percent tax on domestic passenger airline tickets. A portion of the trust fund was appropriated by Congress for the Airport Development Aid Program (ADAP). Under this the second worst ten-year performer. This means that Federal investments in civil aviation related research (FAA and NASA) have been seriously eroded in both absolute terms and in comparison to other transportation modes.

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FIGURE III-3

AIRPORTS GRANTS-IN-AID APPROPRIATIONS

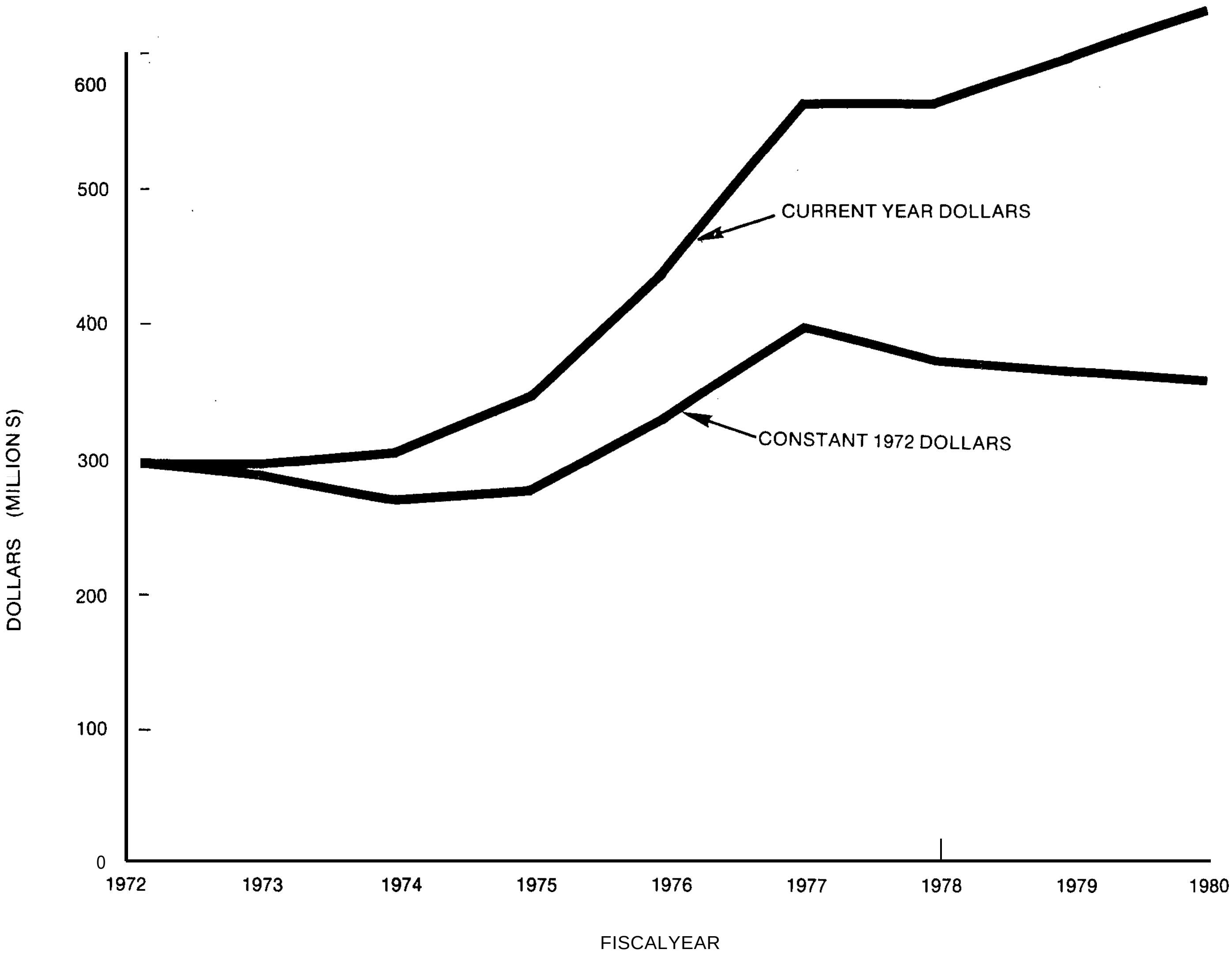
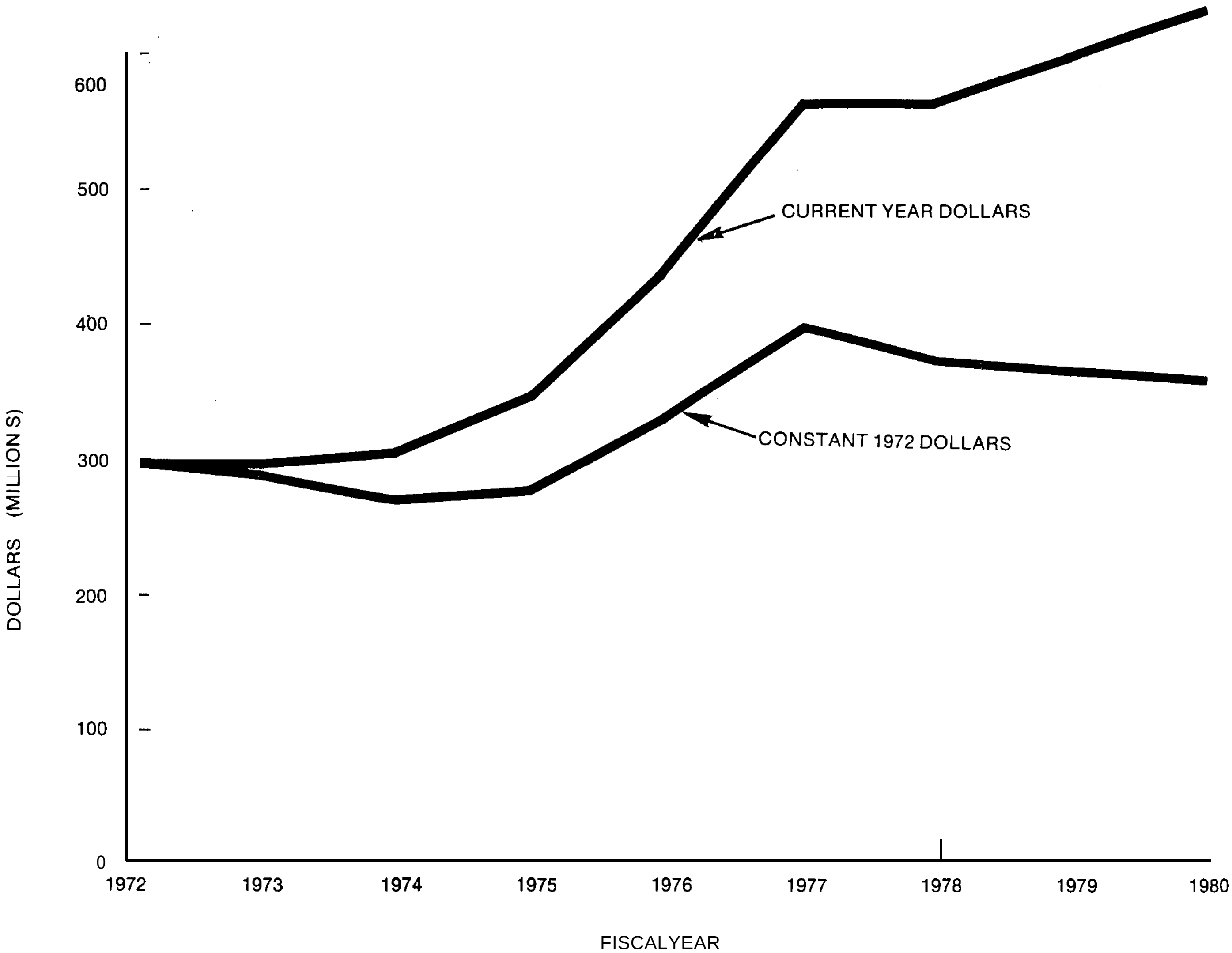


FIGURE III-3

AIRPORTS GRANTS-IN-AID APPROPRIATIONS



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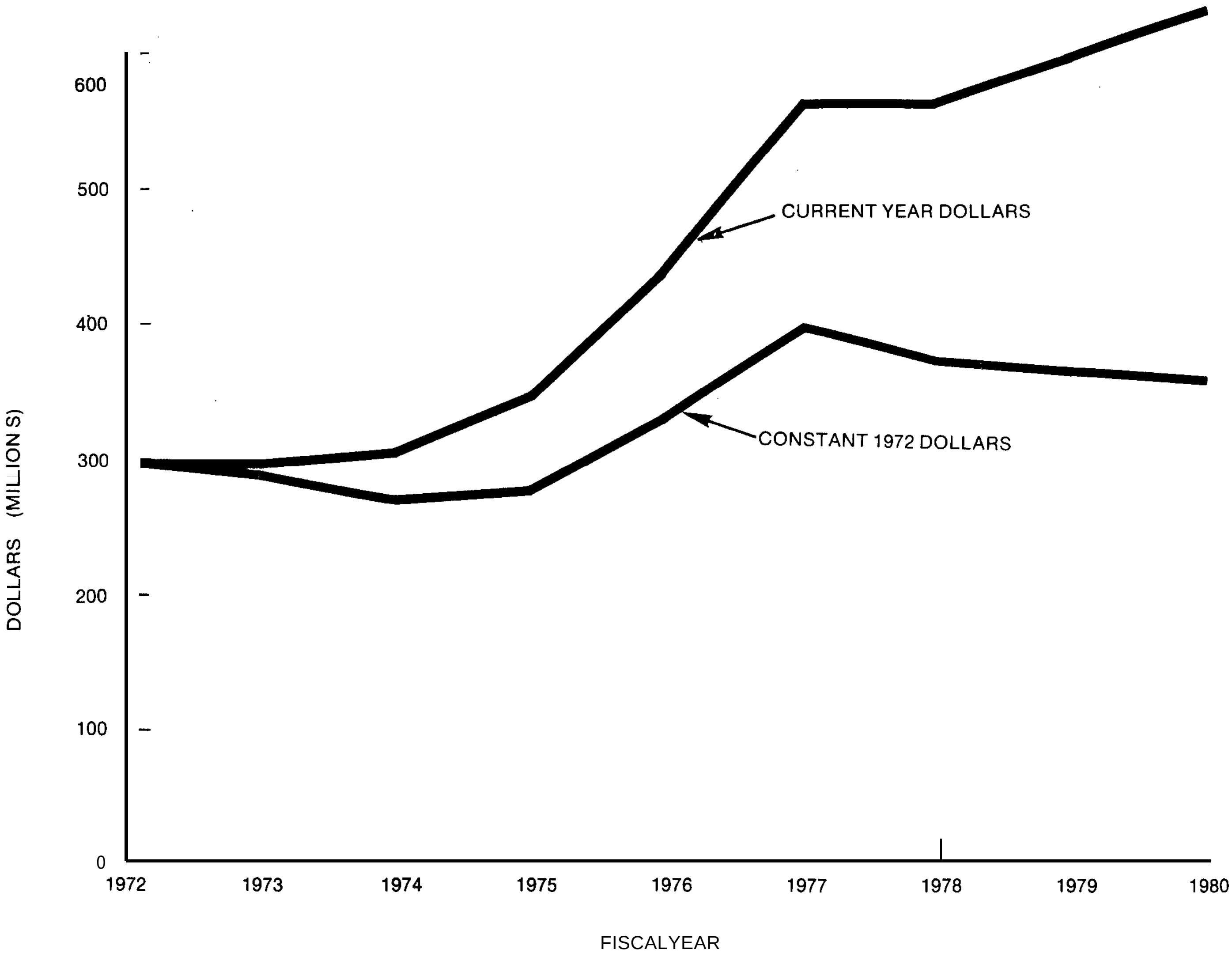

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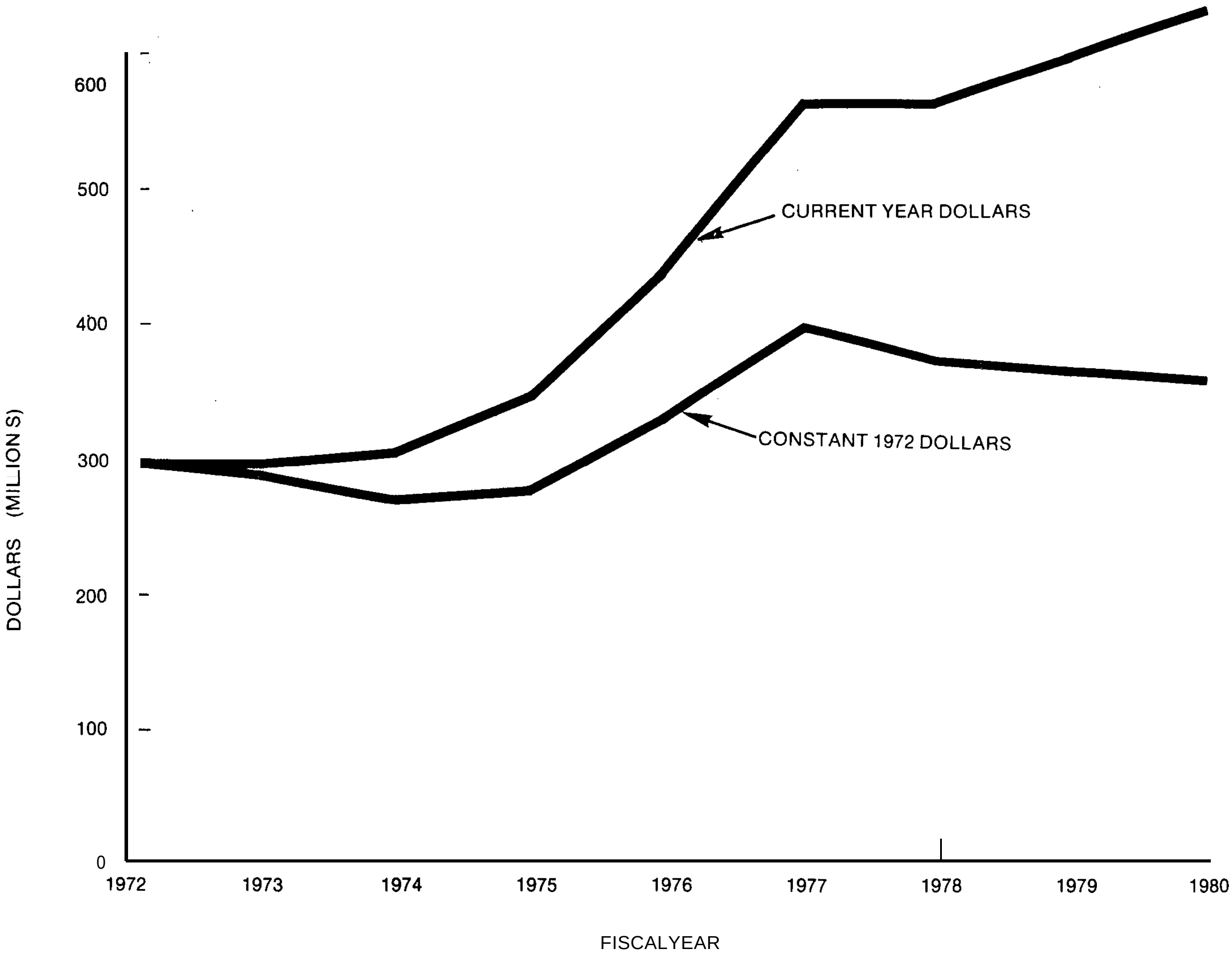


FIGURE III-5

RESEARCH, ENGINEERING & DEVELOPMENT APPROPRIATIONS

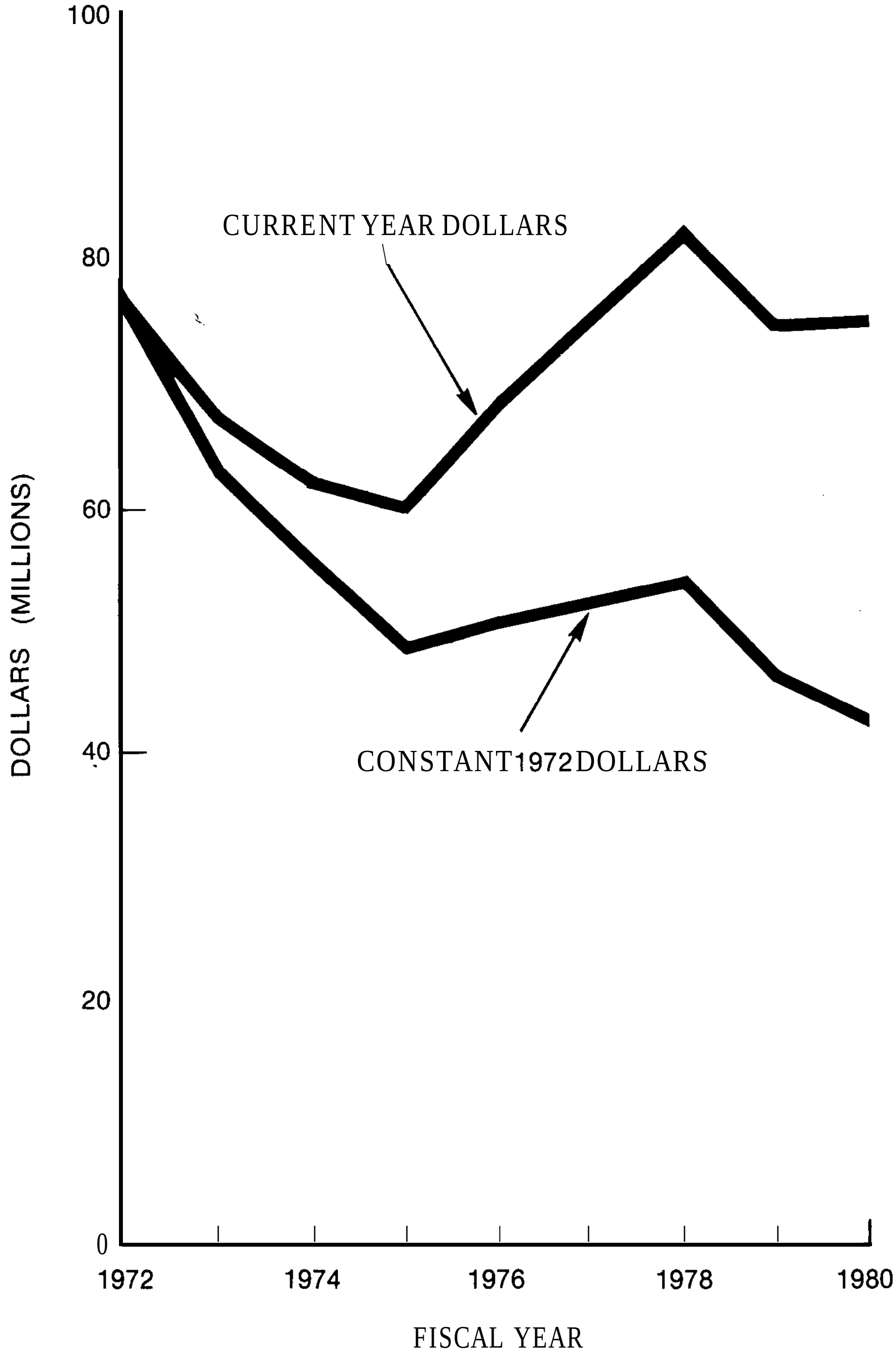
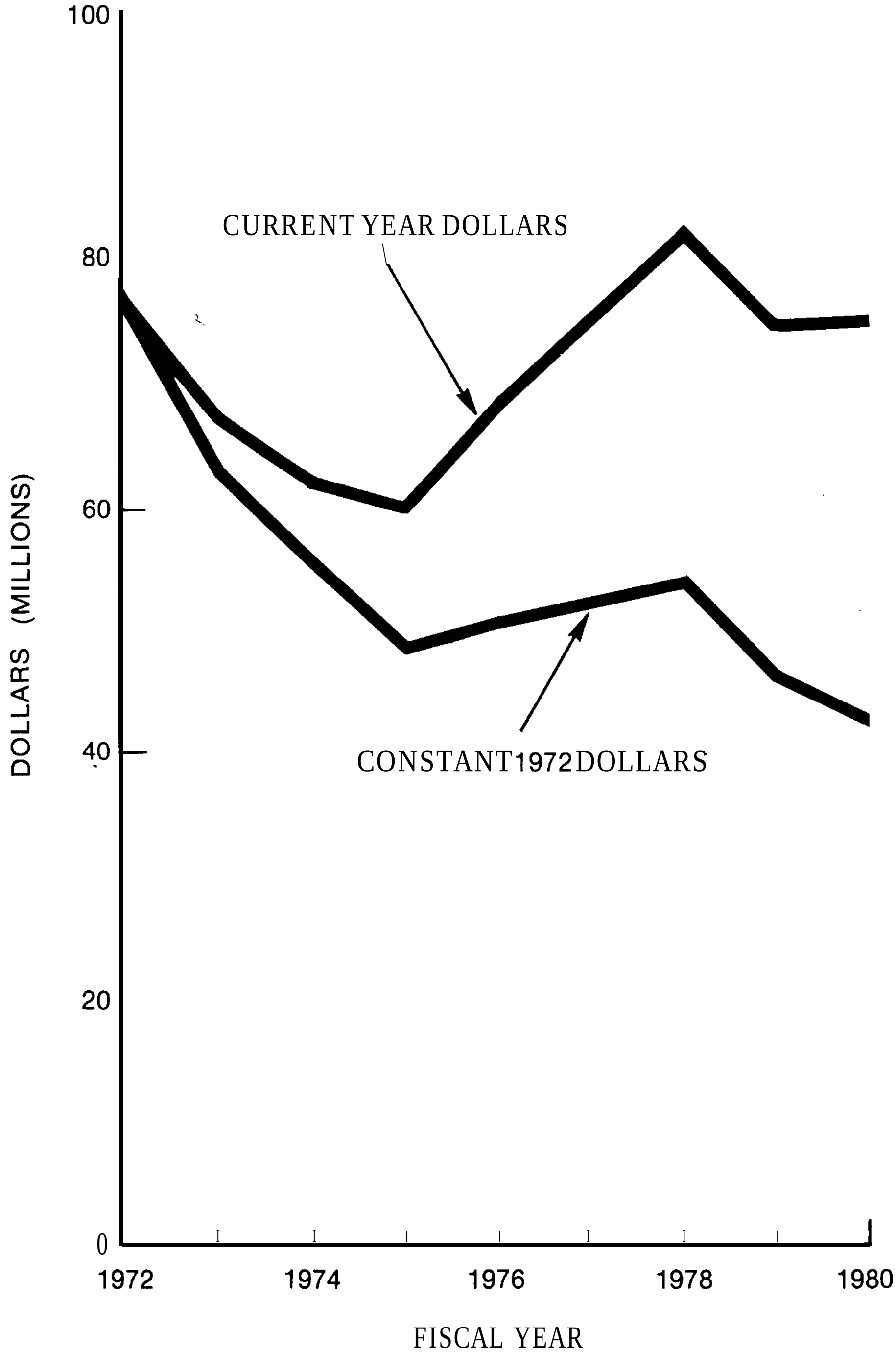


FIGURE III-5

RESEARCH, ENGINEERING & DEVELOPMENT APPROPRIATIONS



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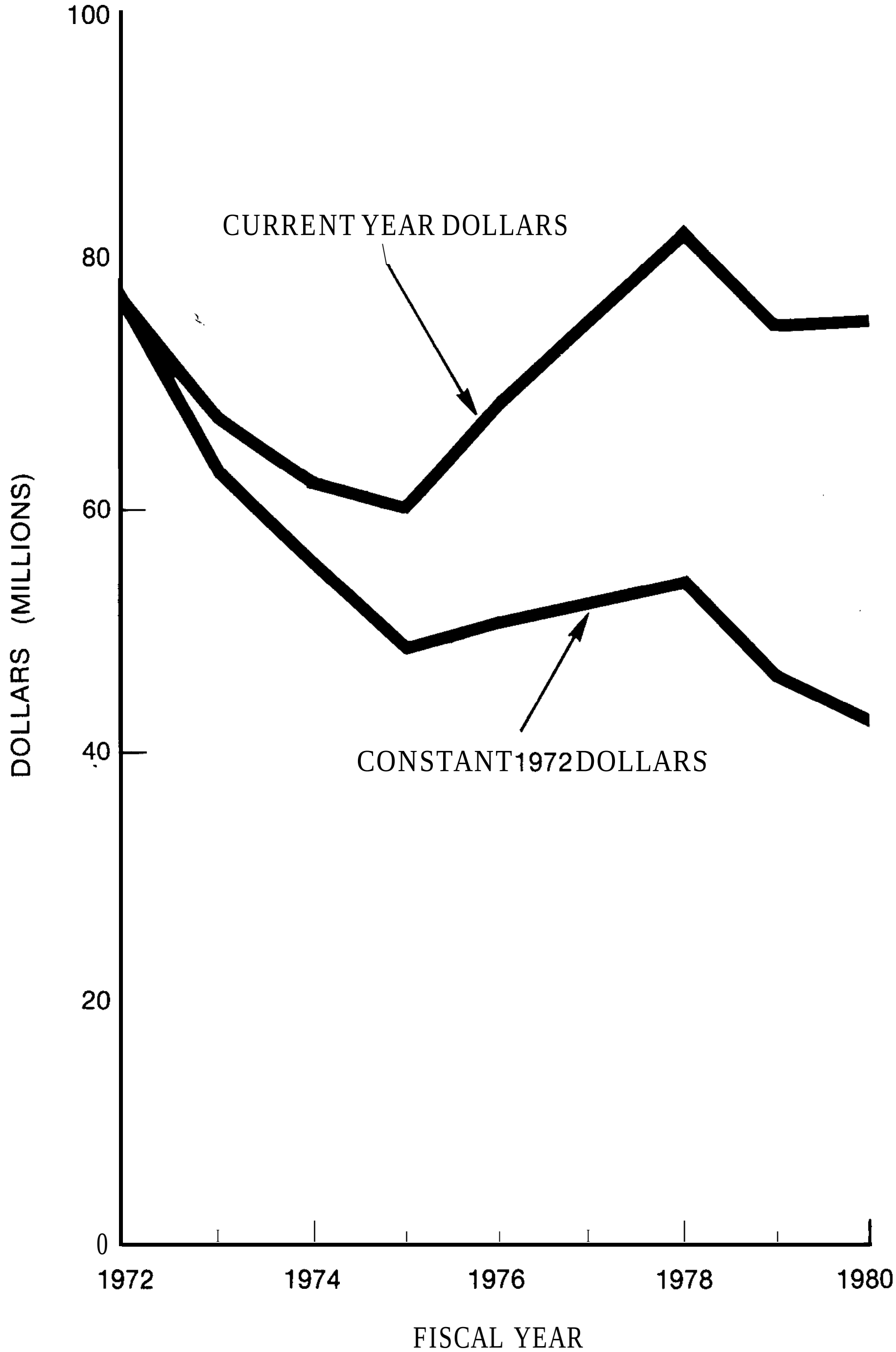
RESEARCH, ENGINEERING & DEVELOPMENT APPROPRIATIONS



3. Expansion -- Existing Technology. The investment policies of this alternative seek to meet growing system demand while holding the level of service quality approximately constant. Included are all capital outlays under "Economic Replacement" plus cost-beneficial upgradings and new establishments. Specifically excluded are all systems not yet ready for acquisition because they require additional research, development and testing or which rely on new technology. Accordingly, this alternative might be dubbed "more of the same." Examples of expenditures under such a policy include establishment of new Instrument Landing Systems and Airport Traffic Control Towers. Programs not included would be the Discrete Address Beacon System and the Microwave Landing System.

4. Expansion -- New Technology. This investment alternative also seeks to satisfy growing demand. It includes all outlays found in "Economic Replacement" and "Expansion-Existing System." In addition, it includes additional projects which utilize new technologies targeted at improving system capacity at critical locations as well as improving system safety. Typical new technologies included are the Discrete Address Beacon System, and the Microwave Landing System.

5. Quality Improvement. This alternative consists primarily of safety oriented projects which employ new technology. A basic characteristic of these projects is that they are independent of other investments and can be undertaken currently or at some future time. Accordingly, this alternative does not incorporate the projects of the other alternatives; rather, it can be annexed to any of the others.

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the projected costs for all programs identified with each alternative yields the cost estimates.

Benefits associated with each alternative are basically related to F&E cost estimates of programs listed in Appendix I. For many agency programs, this is accomplished on the basis of known benefit-cost relationships, which have been independently estimated. For other programs, benefits are assumed to equal costs. In many cases where this assumption is made, the size of the program is relatively small or benefit-cost analysis is currently under development. In other cases, the agency has indicated that a valid requirement is tantamount to a judgmental estimate that benefits of a program are equal to or greater than its cost. This procedure will tend to understate benefits. On the other hand, it must also be realized that when a large program for which a requirement has yet to be validated is assumed to have benefits equal to costs, the benefit estimates may be overstated to the extent that benefits fall below costs. Such a situation may exist for several programs. The presence of this analytical difficulty will be indicated where possibly significant.

In addition to dollar estimates of benefits, the potential number of lives saved and hours of delay avoided under each alternative are reported in Figure III-6. The values in the table are increments associated-with each investment alternative over the next lower one. Because each alternative except "Quality Improvement" presupposes the undertaking of all previous alternatives, the total avoided delays and fatalities are cumulative. These values are shown in parentheses.

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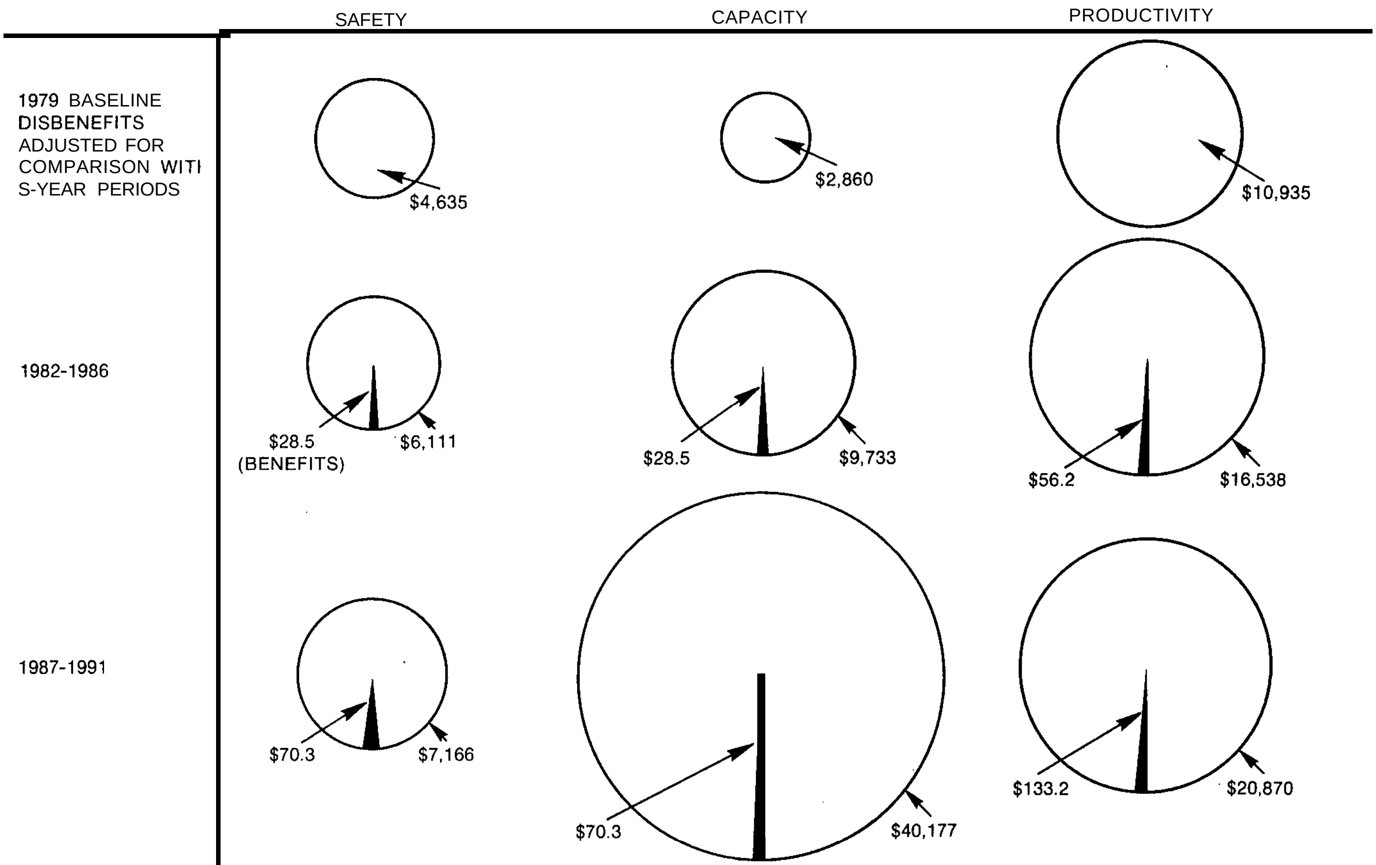
FIGURE III-7

BENEFITS ACHIEVED FROM REPLACE FACILITIES WHEN COMPLETELY WORN OUT
("PHYSICAL WEAR OUT")



NOTES:

1. IN MILLIONS OF CONSTANT 1980 $'s.
2. THE CIRCLES REPRESENT THE DOLLAR DISBENEFITS ACCRUED IF NO CAPITAL INVESTMENTS ARE MADE FOR EXPANDED, NEW OR MODERNIZED FACILITIES.
3. SHADED AREA IN EACH CIRCLE REPRESENTS THE BENEFITS TO BE ACHIEVED FROM CAPITAL INVESTMENTS.

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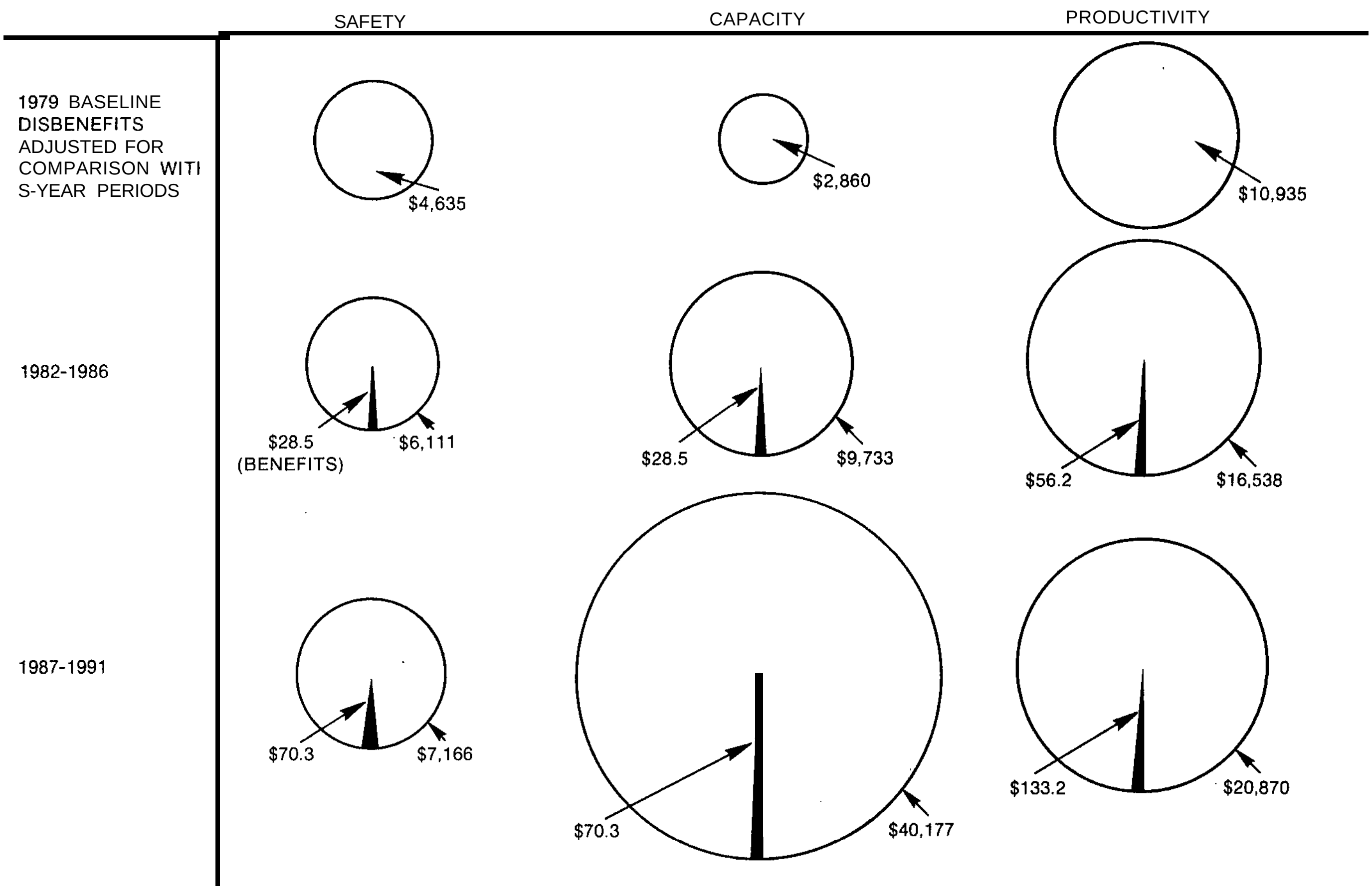

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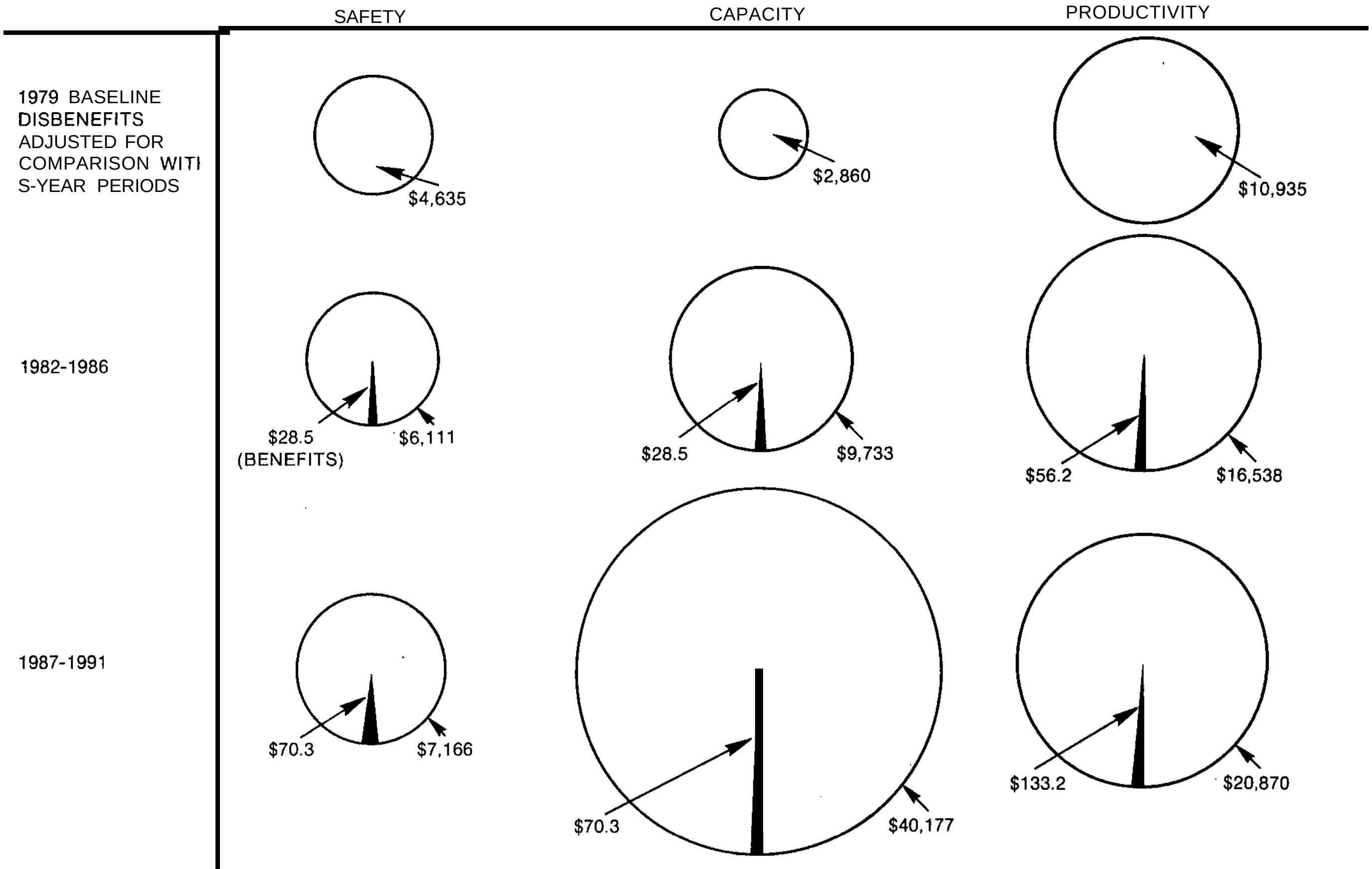

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productivity benefits are expected to total about $700 million while in the 1987 to 1991 period, benefits of $2,027 million are projected. Capacity benefits of $42 million and $131 million are expected for the 1982-1986 and 1987-1991 periods, respectively. Estimated safety benefits are $115 million and $257 million for the two respective periods.

3. Expansion -- Existing Technology. This alternative requires funding of about $2.9 billion (1980 dollars) over the 1982-1986 period and $3.7 billion during the 1987-1991 period. This is equivalent to annual outlays of $570 million and $745 million. As shown in Figure III-9, during the respective five year comparison periods safety benefits will be about $385 and $754 million. Capacity benefits will be $487 and $917 million while productivity gains of $1,062 and $2,640 million should be realized. In terms of physical units, about 687 thousand delay hours will be avoided and about 2,436 fatalities prevented over the 1982-1991 period.

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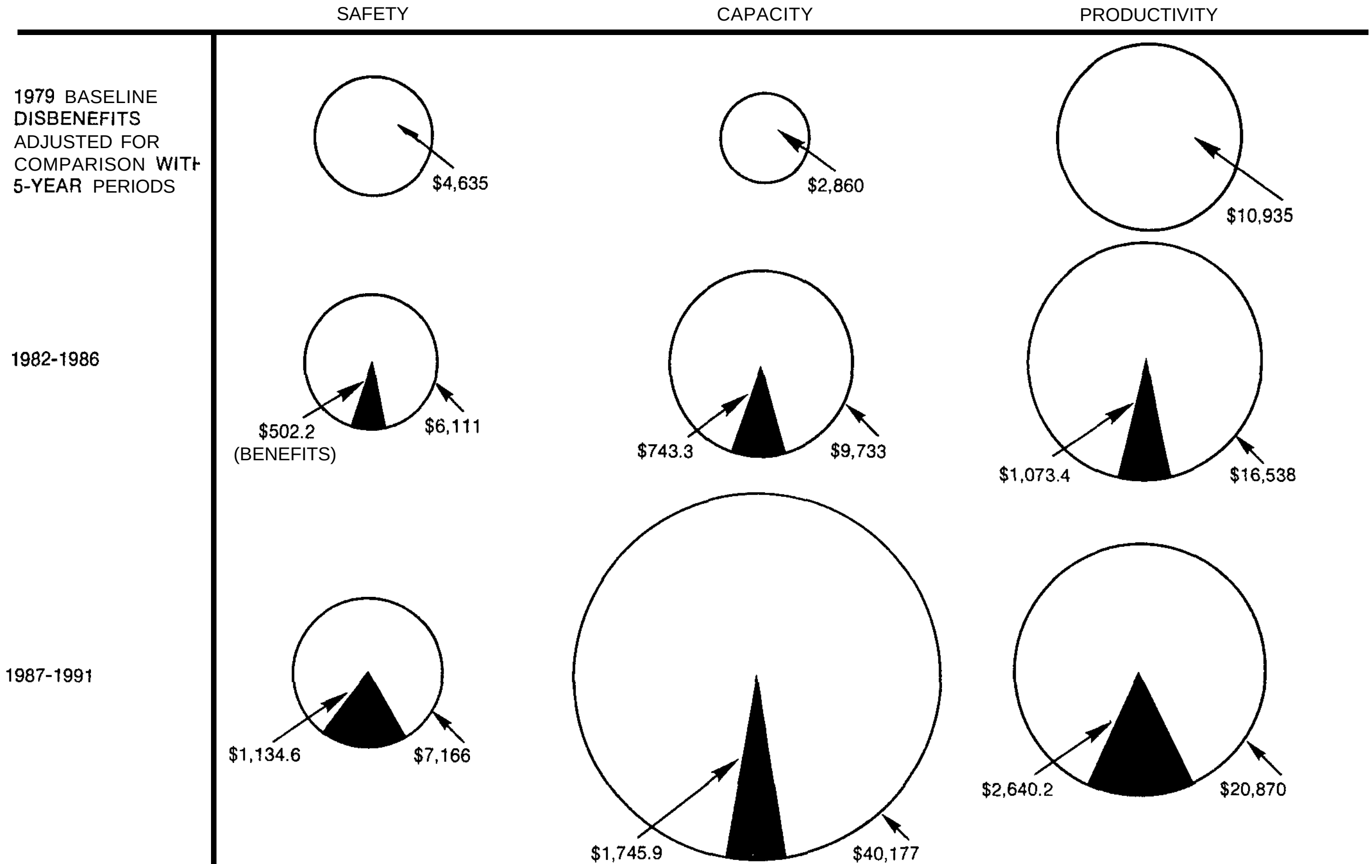
FIGURE III-10

BENEFITS ACHIEVED FROM EXPAND SYSTEM USING NEW TECHNOLOGY
(“EXPANSION - NEW TECHNOLOGY”)



)TES:

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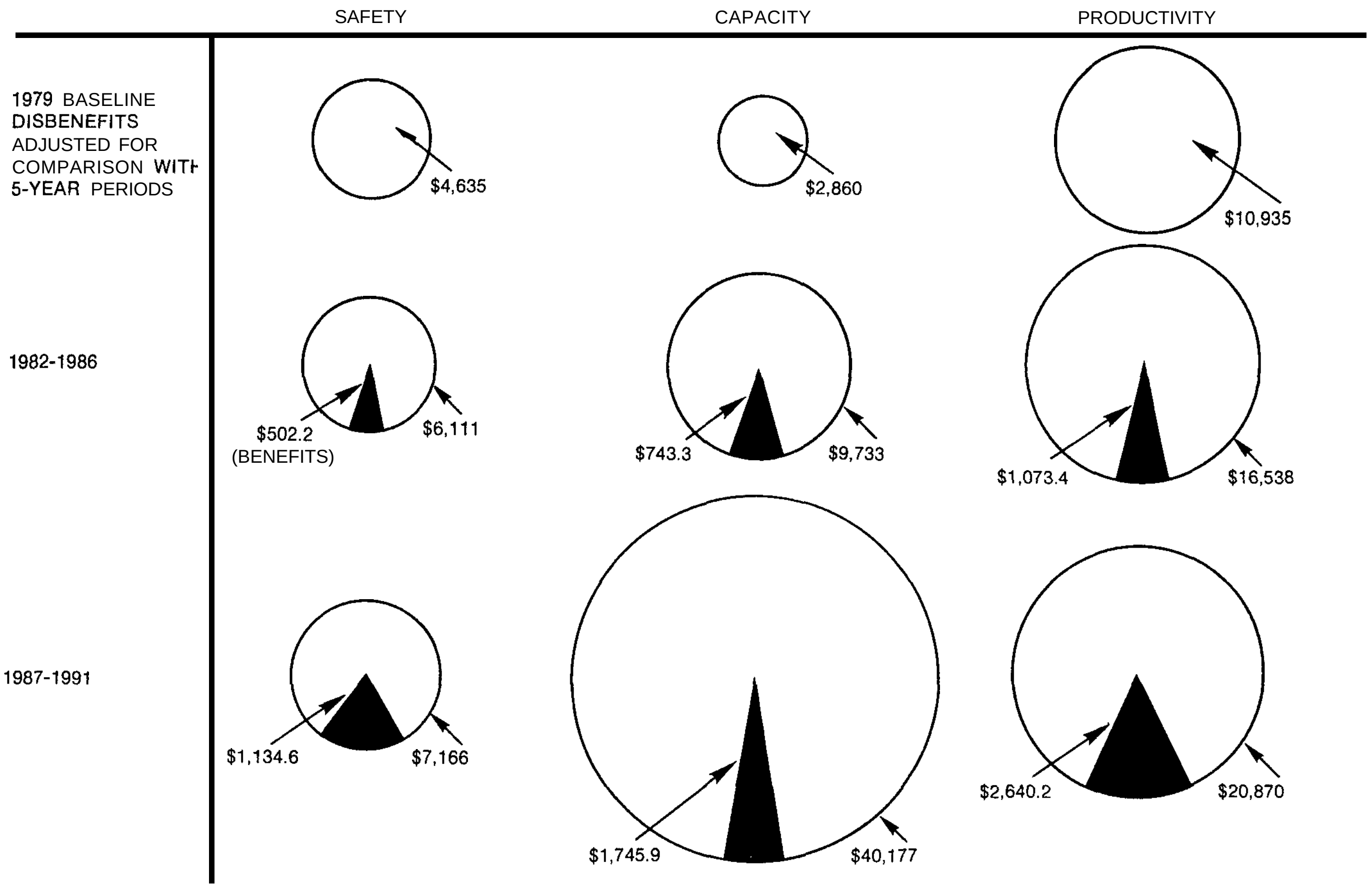

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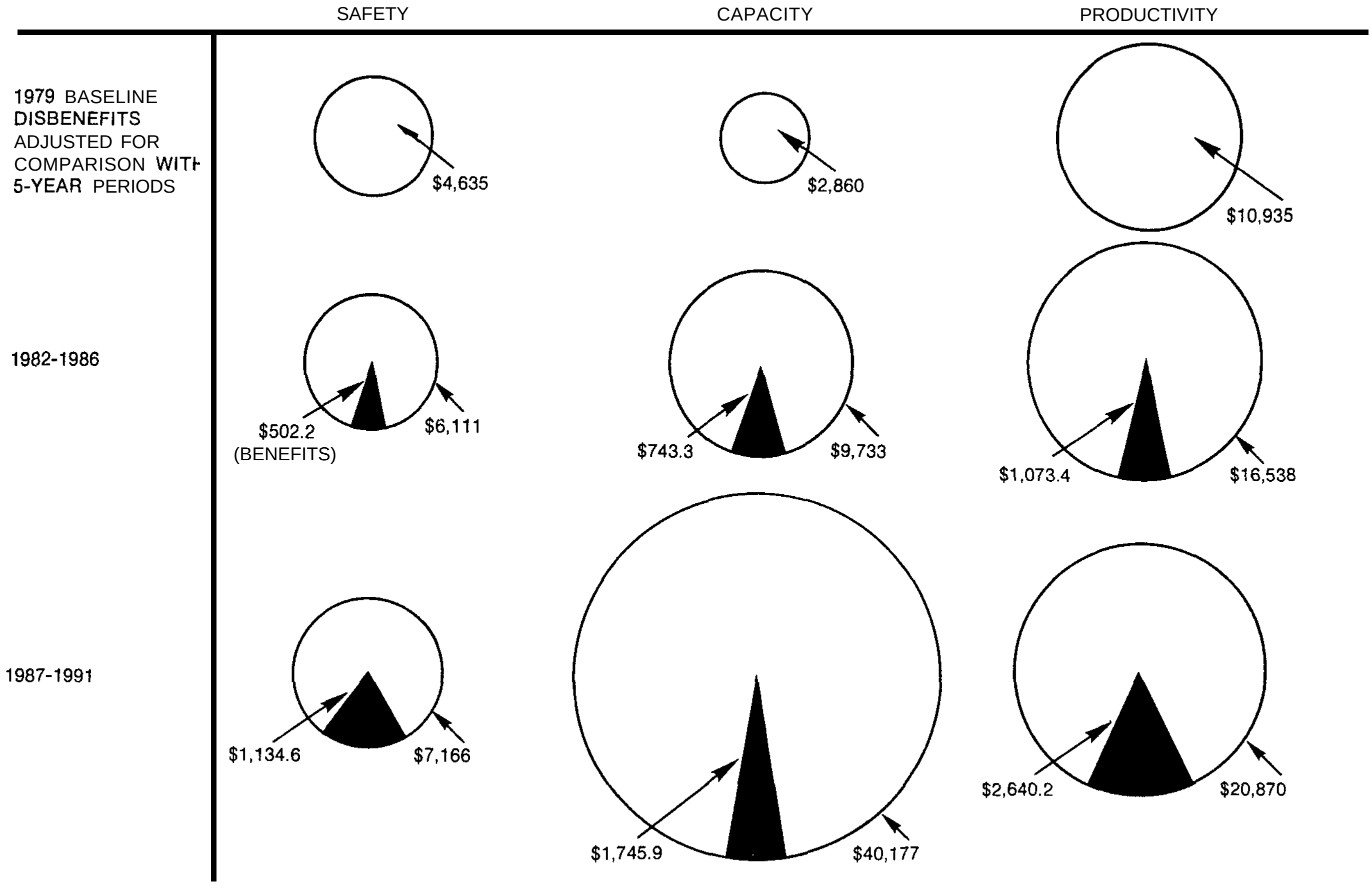

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6. Summary. Total F&E expenditure requirements in constant 1980 dollars for the 1982-1986 and 1987-1991 periods are summarized in Figure III-12. These estimates indicate the cost of F&E investment projects over time net of inflation. The table also shows an estimate for current year dollars.

Benefit estimates associated with each investment alternative are summarized in 1980 dollars for 1982-1986 and for 1987-1991 in Figure III-13. In addition to totals, benefit allocations for major output categories are indicated. As can be seen, if all the investments outlined above were pursued, system performance over the 1982-1986 period will be improved by $642 million in the area of safety, $853 million in capacity, and $1,138 million in operating cost. For the 1987-1991 period, the respective improvements are $1,342, $1,932, and $2,745 million.

(3) Airport Capital Investments.

a. Background. Even if substantial capital investments are made in FAA facilities over the next decade, significant system capacity problems remain. Airport development will be a key to solving this capacity constraint.

Under the Airport and Airway Development Act of 1970, as amended which expired September 30, 1980, the FAA provides airport development grants on a cost share basis with state and local governments. In December 1980, replacement legislation for the 1970 Act was pending before Congress.

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FIGURE III-13
BENEFITS ACHIEVED BY F&E PROGRAMS [a/]
In 1982-1986 and 1987-1991
(Millions of 1980 Dollars)

	Total Benefit		Safety		Capacity		Productivity		Energy/Environment	
	1982-86	1987-91	1982-86	1987-91	1982-86	1987-91	1982-86	1987-91	1982-86	1987-91
Physical Wear Out	114.6	277.3	28.5	70.3	28.5	70.3	56.2	133.2	1.4	3.5
	(391.9) [b/]		(98.8)		(98.8)		(189.4)		(4.9)	
Economic Replacement	898.6	2490.4	114.7	257.1	42.1	130.9	703.1	2026.6	38.7	75.8
	(3389.0)		(371.8)		(173.0)		(2729.7)		(114.5)	
Expansion -- Existing Technology	1978.3	4357.9	384.9	754.0	487.2	916.7	1061.8	2603.0	44.4	84.2
	(6336.2)		(1138.9)		(1403.9)		(3664.8)		(128.6)	
Expansion -- New Technology	2363.4	5604.9	502.2	1134.6	743.3	1745.9	1073.4	2640.2	44.5	84.2
	(7968.3)		(1636.8)		(2489.2)		(3713.6)		(128.7)	
Quality Improvements	314.7	498.1	139.6	206.9	109.6	186.0	64.3	104.2	1.2	1.0
	(812.8)		(346.5)		(295.6)		(168.5)		(2.2)	
TOTAL [c/]	2678.1	6103.0	641.8	1341.5	852.9	1931.9	1137.7	2744.4	45.7	85.2
	(8781.1)		(1983.3)		(2784.8)		(3882.1)		(130.9)	

[a/] Benefit/cost ratios cannot be accurately computed from the data shown in this figure and Figure III-12. Cumulative benefits represent only those which accrue during the 1984-91 time period and do not include life cycle payoffs beyond 1991. Similarly, costs shown in Figure III-12 do not include life cycle components such as operation and maintenance costs.

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The cost of development that was not eligible for Federal aid under the ADAP must be included.

All costs must be adjusted upward to account for inflation.

The development recommendations listed in the published NASP for the 6-10 year period are less complete than those for the shorter range, 1-5 year period, because of the greater difficulty in forecasting needs more than a few years in advance. As a result, the NASP shows uninflated investment requirements during the 6-10 year period that are only about half as much as the requirements of the first five years. In order to compensate for the incomplete nature of the longer term plans, the uninflated investment needs for that period should be increased to equal the level of the first five years.

Since the NASP only includes development that was eligible for Federal aid under the ADAP, it excludes the cost of other necessary airport development such as the revenue producing part of the terminal building, parking lots, hangars, and air cargo buildings. A study [1] recently prepared for the FAA examined these costs and developed a method for estimating them which was used to develop Figure III-15.

1/ Investment Needs and Self-Financing Capabilities: U.S. Airports Fiscal Years 1981-1990, Crenshaw and Dickinson, July 1978, Order No.: WI-78-3421-1.

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1/ Investment Needs and Self-Financing Capabilities: U.S. Airports Fiscal Years 1981-1990, Crenshaw and Dickinson, July 1978, Order No.: WI-78-3421-1.

The cost of development that was not eligible for Federal aid under the ADAP must be included.

All costs must be adjusted upward to account for inflation.

The development recommendations listed in the published NASP for the 6-10 year period are less complete than those for the shorter range, 1-5 year period, because of the greater difficulty in forecasting needs more than a few years in advance. As a result, the NASP shows uninflated investment requirements during the 6-10 year period that are only about half as much as the requirements of the first five years. In order to compensate for the incomplete nature of the longer term plans, the uninflated investment needs for that period should be increased to equal the level of the first five years.

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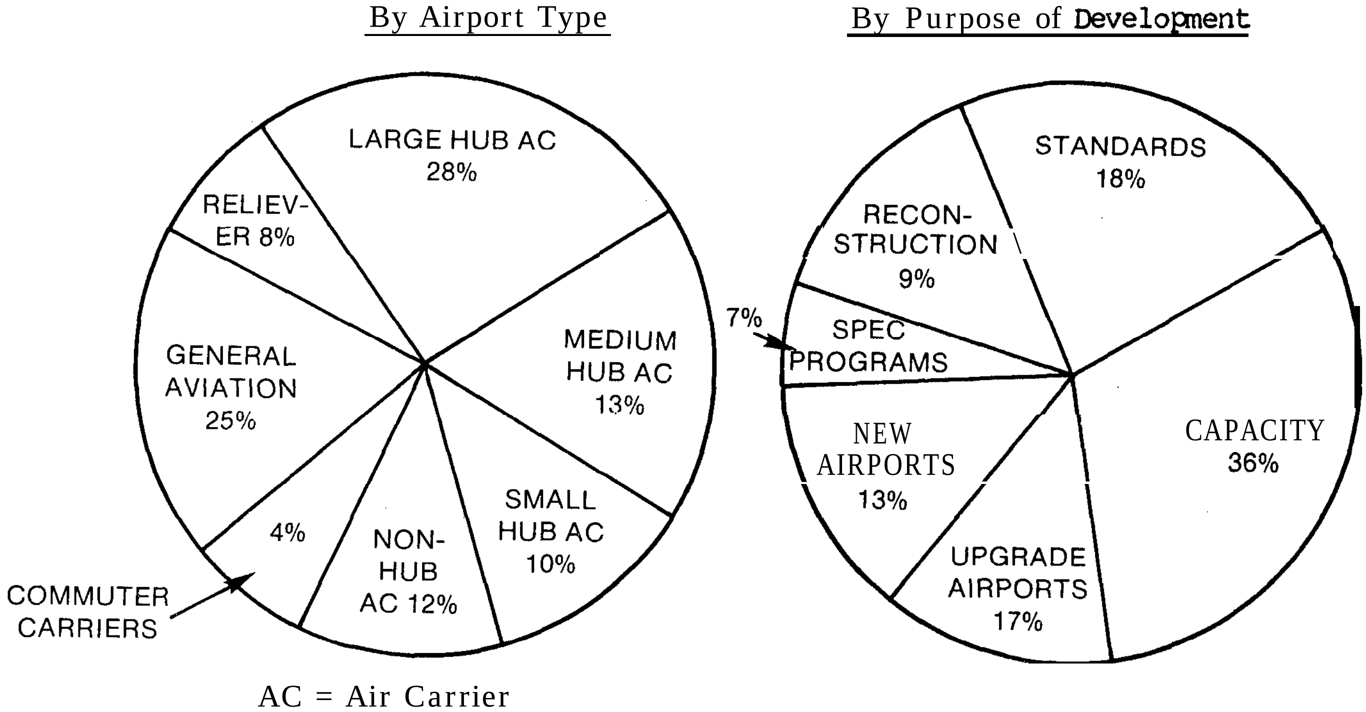
1/ Investment Needs and Self-Financing Capabilities: U.S. Airports Fiscal Years 1981-1990, Crenshaw and Dickinson, July 1978, Order No.: WI-78-3421-1.

FIGURE III-16

Distribution of National Airport System Plan (NASP) Costs

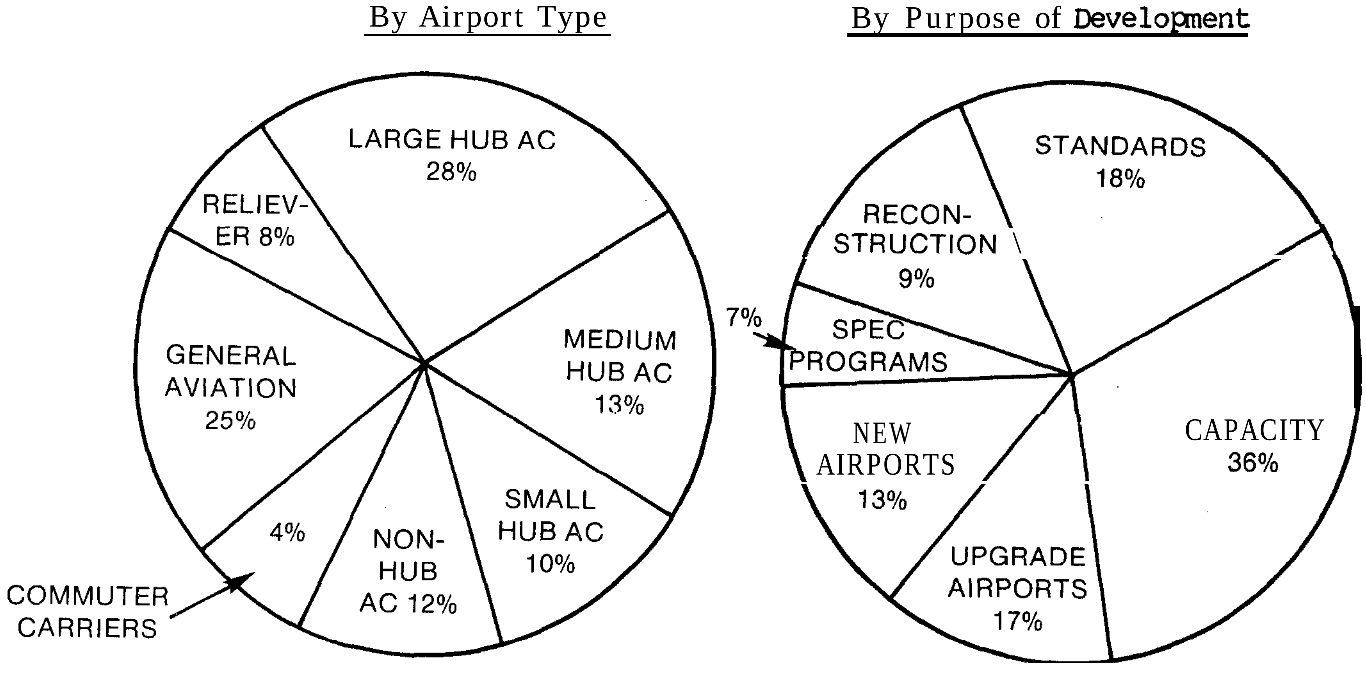


(2) Facilities and Equipment.

a. Trends and Projections. As previously indicated, investment in FAA Facilities and Equipment (F&E) has declined substantially in constant dollars over the past decade (Figure III-4). While actual dollar levels have remained reasonably constant, the impact of inflation has reduced the purchasing power of these dollars to barely a third of FY-1972 levels. This decline in real capital investment occurred during a period of significant growth in aviation activity and a consequent doubling in the demand for aviation services.

This level of F&E investment over the past decade has resulted in an aging inventory of equipment, requiring higher levels of maintenance attention and increased costs. Continued low investment levels will result in an inability to provide enhancements in system safety, capacity and productivity, as well as a reliance upon older equipment whose costs will rapidly escalate in the next decade.

FIGURE III-16
Distribution of National Airport System Plan (NASP) Costs



AC = Air Carrier

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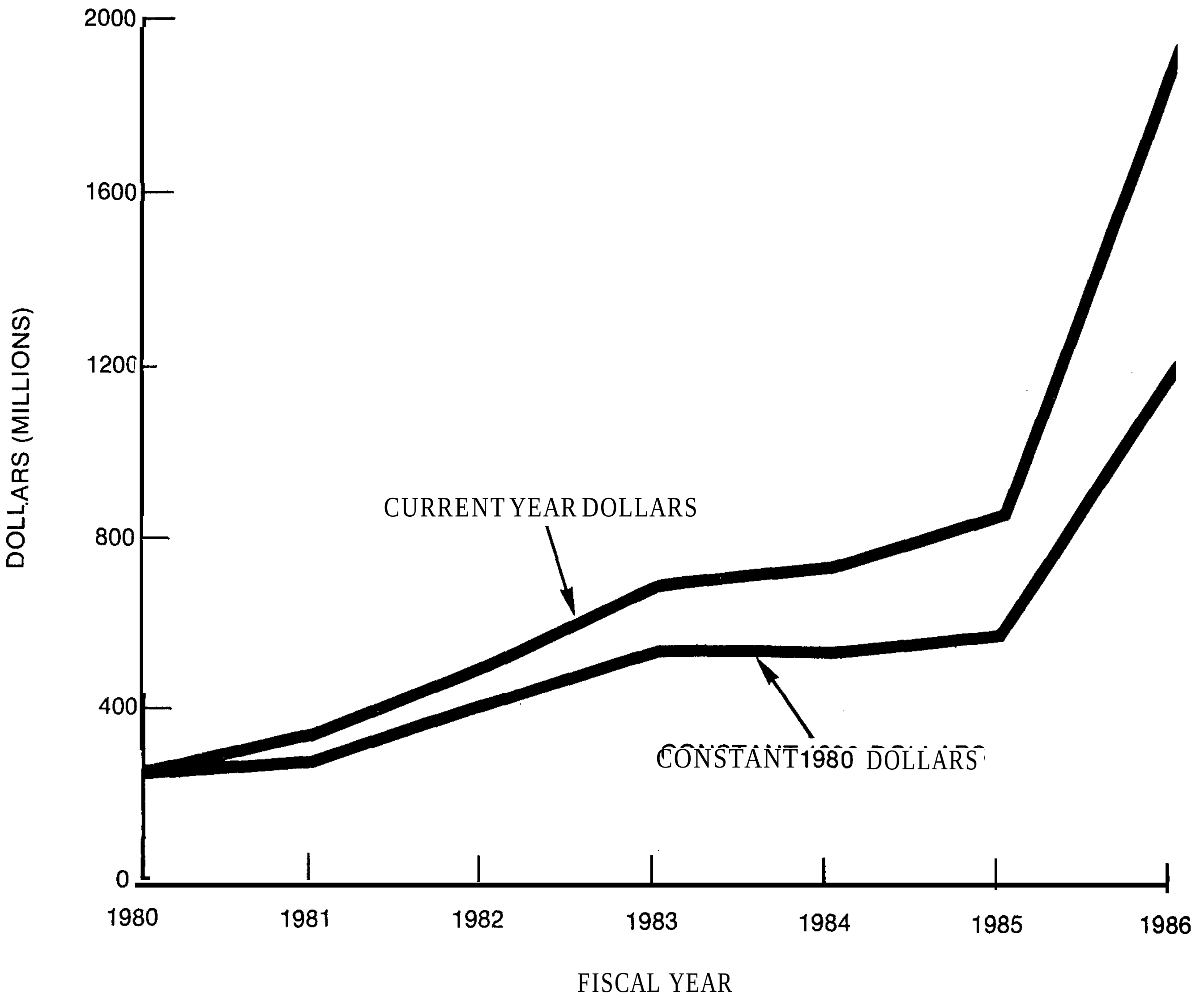
FIGURE III-17

F&E FUNDING REQUIRED TO ACHIEVE PROPOSED IMPROVEMENTS TO THE NATIONAL AIRSPACE SYSTEM



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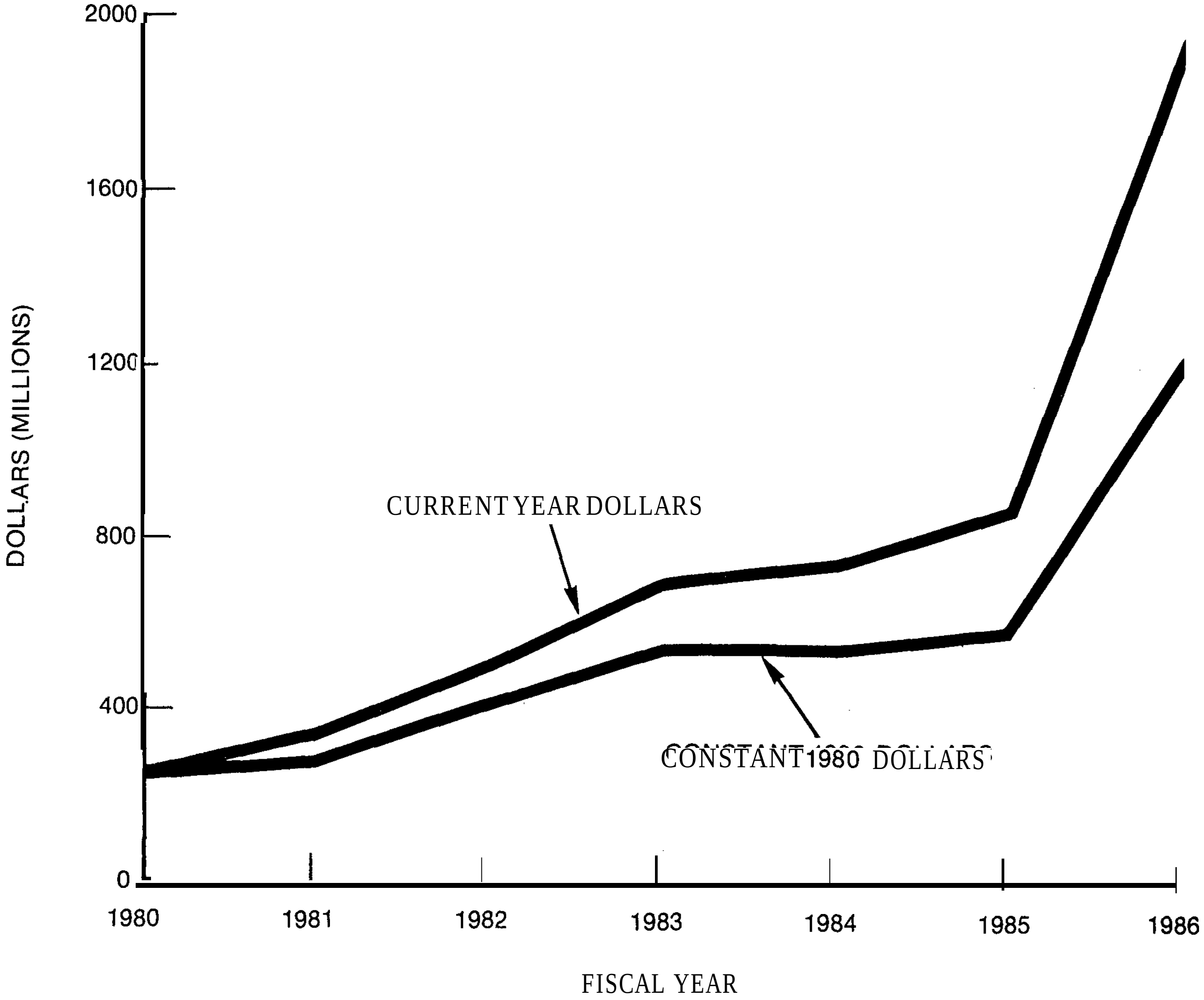
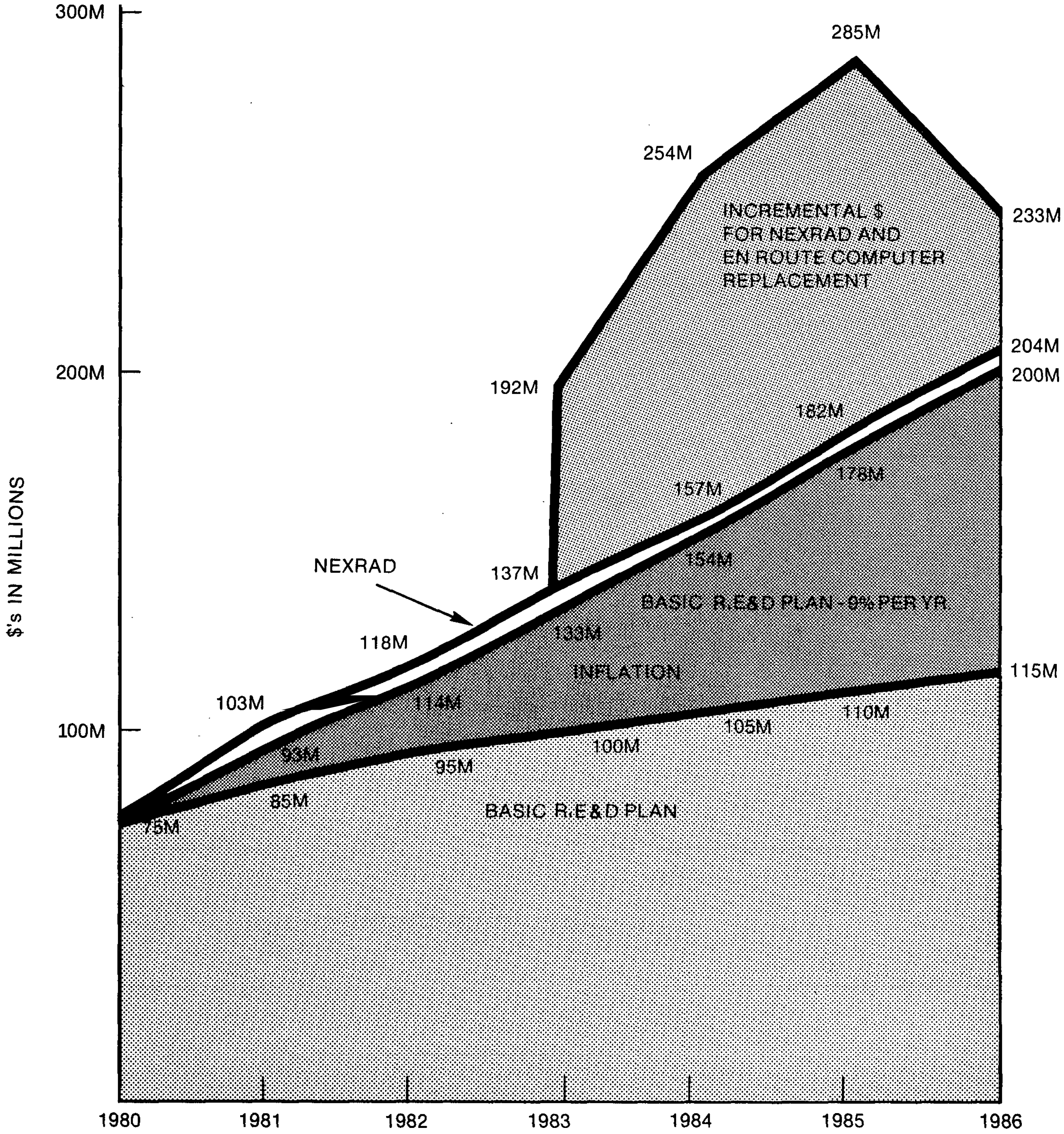


FIGURE III-18

R,E&D FUNDING REQUIRED TO SUPPORT PROPOSED IMPROVEMENTS TO THE NATIONAL AIRSPACE SYSTEM



FISCAL YEARS

Provide substantial increase in system capacity and reduce delays, especially in the airport, terminal airspace, and in the landside areas.

Substantially increase system performance and productivity and reduce the rate of increase in cost for users to fly in the system.

Improve efficiency in the use of airspace in order to reduce fuel consumption and further reduce delays.

The results of studies performed, test and evaluation of breadboard and prototype equipment and actual field operational tests of a number of E&D products demonstrate a potential for significant gains in safety, capacity, controller productivity, efficient use of airspace, and an associated reduction in certain FAA user costs.

The Research, Engineering and Development programs are divided into four areas as they relate to:

Safety - (Figure III-19)
Capacity - (Figure III-20)
Productivity - (Figure III-21)
Fuel Conservation - (Figure III-22)

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Capacity - (Figure III-20)

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Capacity - (Figure III-20)
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Fuel Conservation - (Figure III-22)

FIGURE III-20

R,E&D Capacity Related Activities

Technical Goals	E&D Activity
Increase Airport Capacity	
Develop capability of detecting/predicting conditions where longitudinal separation standards may be reduced without degrading safety due to possible encounter with high energy wake vortices.	- Wake Vortex Avoidance System (WVAS)
Improve accuracy in the delivery of aircraft to the runway threshold and maintain closer tolerances in separation of aircraft during approach.	- Airport Capacity Delay Program - Terminal Integrated Flow Management - Integrated Flow Management (IFM)
Minimize the impact of low visibility on the ability of the local controller and ground controller to control surface traffic and to determine when the runway is clear for another operation.	- Airport Surface Traffic Control (ASTC) System - Terminal Automated Ground Surveillance System (TAGS) - Airport Transgression
Reduce operational constraints associated with the use of today's VHF Instrument Landing System at some airports.	- Microwave Landing System
Provide wake avoidance information	- Wake Vortex Avoidance System (WVAS)
Increase Efficiency In Airspace Utilization	
Minimize enroute distance and delay from gate of departure airport to landing.	- Integrated Flow Management - En Route Metering - Airport Configuration - Management - Terminal Integrated Flow Management - Central Flow Control
Evaluate AX/Airport Airside Capacity Versus Ground Transportation Landside Capacity	
Develop capacity/delay models for both airside and landside analysis.	- Airport Airside and Airport Landside capacity/delay models - Airport Requirements

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FIGURE III-21
R,E&D Elements To Increase Productivity

Technical Goals	Activity
Improve Controller Productivity	
Pursue a development program that will make evolutionary improvements to the semi-automated en route, terminal area and central control facilities to increase the overall productivity of the facilities.	- Electronic Tabular Display Automated Flight Data Handling and Distribution Metering and Sequencing in Terminal Areas - Automatic Generation and Delivery of ATC Messages (DABS/D/L/) - AERA - Flight Data and Display (FDAD) - Terminal Information and Display System (TIDS)
Reduce Costs and Improve Services At Flight Service Stations	
Automate some of the weather inputs to FSS's	- Automated Weather Observation Systems
Automate and consolidate FSS's at 61 locations	- Flight Service Station Program
Develop ways for pilots to receive automated briefings via inexpensive briefing terminals	- Pilot Self Briefing System
Reduce Maintenance Costs	
Analyze how maintenance procedures might be changed as more reliable equipment is installed to reduce maintenance costs	- Future Maintenance Concepts (RMMS)
Reduce ADAP costs of rebuilding runways	- Improved Airport Pavement Designs
Near Term ATC Communications Improvements	
Replace existing voice communications systems	- SVSS - Tone Channeling Improvements - FSS VSCS - Terminal VSCS - En Route VSCS
Improve existing data communications systems.	- NADIN Enhancements

FIGURE III-21
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FIGURE III-23

Federal Funding Needs 1982-1991
(Billions of Dollars)

	Current Dollars (Wharton Estimate)	Constant 1980 Dollars
Facilities and Equipment		
Physical Wear Out	$ 0.8	$ 0.4
Economic Replacement	7.1	4.0
Expansion--Existing Technology	11.3	6.6
Expansion--New Technology	13.4	7.7
Quality Improvement	1.3	0.8
Total F&E Program a/	$ 14.7	$ 8.5
Airport Grants-In-Aid Program b/	$ 9.8	$ 5.9
Research, Engineering and Development Program	$ 2.6	$ 1.6
TOTAL	$ 27.1	$ 16.0

a/ Total includes only "Expansion--New Technology" and "Quality Improvement"
b/ Figures shown are Federal share and represent 80 percent of total required funding

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FIGURE III-24

SYSTEM PERFORMANCE UNDER ALTERNATIVE FACILITIES AND EQUIPMENT EXPENDITURE OPTIONS
(Millions of 1980 dollars)

	No Investment (1)	Physical Wear Out (2)	Economic Replace-ment (3)	Expansion--Existing Technology (4)	Expansion--New Technology (5)	Total Program a/ (6)
1982-1986						
Accident Cost	6,111	6,083	5,996	5,726	5,609	5,469
Delay Cost	9,733	9,705	9,691	9,246	8,990	8,880
Operating Cost	16,538	16,482	15,835	15,476	15,465	15,400
1987-1991						
Accident Cost	7,166	7,096	6,909	6,412	6,031	5,824
Delay Cost	40,177	40,107	40,046	39,260	38,431	38,245
Operating Cost	20,870	20,737	18,843	18,267	18,300	18,126

a/ Total includes "Expansion--New Technology" and "Quality Improvements"

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CHAPTER IV: NATIONAL AVIATION SYSTEM PROGRAMS

A. GENERAL DESCRIPTION. Guaranteeing safe and efficient movement of aircraft is the foundation upon which the Nation's air transportation system is built. The quest for safety in aviation permeates all of FAA's activities and guides every decision. The safety impact is always the first measure applied to any program, even those without a direct safety goal, such as those designed to increase capacity, reduce aircraft noise, or improve controller productivity. These programs also include safety benefits just as safety programs often contribute toward the attainment of other goals.

The FAA's primary programs fall into seven major areas:

En Route

Terminal

Flight Services

Technical Support

Research and Development

Airports

Personnel

Programs in these seven areas are described in the following paragraphs. With the exception of minor adjustments in the timing of a few capital projects, these programs are consistent with those included in the Chapter III needs analysis.

B. EN ROUTE. The en route system includes a comprehensive array of capital investment programs designed to provide needed system enhancements as well as replace obsolete equipment having high

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a nationwide basis. All programs, except for VSCS will be completed in the first five year period. VSCS will be accomplished in the second five years.

The costs of these programs are estimated to total:

	FY-80 Dollars		Current Year Dollars	
	F&E	R,E&D	F&E	R,E&D
FY 1982-86	$ 110 M	$ 49 M	$ 150 M	$ 65 M
FY 1987-91	$ 105 M	$ 45 M	$ 200 M	$ 87 M

(5) Navigation. The major establishment/replacement program for en route navigation during the early part of this ten year program involves the second generation (solid state) VORTAC system, which will have a remote maintenance monitoring capability and will significantly reduce maintenance costs. This program was funded prior to the start of the ten year period and installations should be completed by the mid 1980's. The R,E&D effort in support of long distance navigation, both CONUS and worldwide, will emphasize the experimental and analytical activity needed to formulate a 1982 preliminary United States recommendation regarding the mix of navigation systems for the 1990's and beyond. A final recommendation will be made in 1986 and will involve consideration of the role of VOR/DME, LORAN C, GPS and Omega beyond 1995.

The costs of these programs are estimated to total:

	FY-80 Dollars		Current Year Dollars	
	F&E	R,E&D	F&E	R,E&D
FY 1982-86	$ 65 M	$ 28 M	$ 85 M	$ 39 M
FY 1987-91	$ 75 M 1/	$ 41 M	$ 145 M	$ 82 M

1/ Future program dependent upon recommended alternatives.

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	FY 1982 - 1986	FY 1987 - 1991
VOICE COMMUN-ICATION	- Solid State Transmitters & Receivers & Higher Gain Antennas For All Air/Ground Sites* - Remote Communications Air/ Ground (RCAG) Remote Monitoring Subsystem (RMS) * - Maintenance Processor Subsystem (MPS) * - Voice Switching & Control System (VSCS) (Tone Signaling & Control System)	- VSCS (En Route)
DATA COMMUN-ICATION	- NADIN IA - Provides Data Communications For The Flight Service Automation System (Model II) & The Flight Data Input Output (FDIO System)	- NADIN Enhancements - Provides Data Communications For For National Flight Data Center (FINAL), Computer B, Modernized Weather Service, RMMS (MPS-MPS) , DOT Data Communications Networks

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Alert and Minimum Safe Altitude Warning to ARTS-II facilities, increasing capacity where needed, adding improved digital displays, adapting the tracking capability to make best use of new DABS surveillance inputs and the Terminal Information and Display System (TIDS). In the late 1980's, new data processing systems and associated facilities will be procured to replace the older obsolete equipment which is expected to become increasingly less reliable and more costly to maintain.

The costs of these programs are estimated to total:

	FY-80 Dollars		Current Year Dollars	
	F&E	R,E&D	F&E	R,E&D
FY 1982-86	$ 150 M	$ 41 M	$ 205 M	$ 56 M
FY 1987-91	$ 750 M	$ 93 M	$1400 M	$ 155 M

(2) Airport Surveillance. In the surveillance area, the older, obsolete and maintenance intensive ASR-4, 5 and 6's will be replaced by a new modern ASR-9 radar with an improved moving target detection (MTD) and remote maintenance monitoring (RMM) capability. MTD and RMM will also be added to existing ASR 7 and 8's. Implementation of the improved beacon surveillance system, DABS, will be initiated along with an associated and integrated capability for automatically providing aircraft traffic advisory, and resolution service (ATARS) assurance messages to pilots. A new airport surface detection radar (ASDE-3) will replace the older, lower performance radar (ASDE-2) and will also be installed at other qualifying airports. An automated weather observation capability will be implemented. Two new capabilities are scheduled for procurement during the last five year period, namely a beacon based airport surface surveillance system (TAGS) and, possibly, a special application terminal doppler weather radar.

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(2) Airport Surveillance. In the surveillance area, the older, obsolete and maintenance intensive ASR-4, 5 and 6's will be replaced by a new modern ASR-9 radar with an improved moving target detection (MTD) and remote maintenance monitoring (RMM) capability. MTD and RMM will also be added to existing ASR 7 and 8's. Implementation of the improved beacon surveillance system, DABS, will be initiated along with an associated and integrated capability for automatically providing aircraft traffic advisory, and resolution service (ATARS) assurance messages to pilots. A new airport surface detection radar (ASDE-3) will replace the older, lower performance radar (ASDE-2) and will also be installed at other qualifying airports. An automated weather observation capability will be implemented. Two new capabilities are scheduled for procurement during the last five year period, namely a beacon based airport surface surveillance system (TAGS) and, possibly, a special application terminal doppler weather radar.

In addition to the aforementioned terminal improvements, there will be improvements realized through the use of advanced avionics. The use of head-up displays (HUD's) may be implemented in air carrier and perhaps other aircraft dependent on the results of an R,E&D funded effort to explore the merits of such equipment. Increased safety during low visibility approaches and landings may be possible. The display of air traffic information to the pilot using ground surveillance data sent to the aircraft via DABS data link is also being explored. This latter program may have some impact on the F&E program in the last five year period but decisions in that regard still have to be made.

The costs of these programs are estimated to total:

	FY-80 Dollars		Current Year Dollars	
	F&E	R,E&D	F&E	R,E&D
FY 1982-86	$ 510 M	$ 24 M	$ 710 M	$ 32 M
FY 1987-91	$ 525 M	$ 31 M	$1050 M	$ 60 M

A listing of the improvement programs that will be made during both the first five years (FY 1982-1986) and the following five years (FY 1987-1991) is shown in Figure IV-2. All programs shown require an integrated and supportive developmental effort except for those identified by an asterisk. In those latter cases, the improvements will be attained by the purchase or relocation of facilities where development was completed with pre FY-1981 R,E&D funds or where facilities/equipment were available directly from industry without the need for FAA R,E&D programs. Programs are listed in two columns (1981-1986 and 1987-1991) according to the period when funds are required rather than when they will be completed. Programs shown in both columns indicate that funding will be required in both periods.

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D. FLIGHT SERVICES. The principal programs of the FAA which support the provision of preflight and inflight services primarily to non air carrier pilots and air crews are related to or are part of the flight service station (FSS) automation and modernization program.

Flight Service Station (FSS). The FSS automation and modernization program is to be implemented in three phases each building on the previous phase. The first phase, Model 1, is to be deployed at 41 Level III FSS's. It provides the specialist with retrieval and display of weather and aeronautical data and flight plan entry and processing.

Model 2, full automation, is to be deployed at 61 FSS's located at airports which are major centers of general aviation activity. The specialist will have, in addition to the Model 1 capabilities, weather radar, weather graphics and additional aeronautical information and processing.

The Model 2 system has the capacity to handle the long-term flight service demand either from the specialist or directly from the pilot. It also provides software and interface to support direct user access to the system (Model 3).

The Research and Development program in Flight Service Stations is primarily oriented toward the development of Model 3. Model 3 has three major subdivisions:

User Self-Briefing via computer terminals called Direct User Access Terminals (DUATS)

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E. TECHNICAL SUPPORT. Technical support includes updating the FAA aircraft fleet, associated avionics, and support equipment to provide flight inspection of navigation aids, flight training, research support and related activities. The funding of this program is by two separate appropriations: (1) Facilities and Equipment - F&E, and (2) Facilities, Engineering and Development - F,E&D. The basic difference between these appropriations is that the F&E is funded from the aviation trust fund and the F,E&D is funded from the general revenue operations appropriation.

The F&E funded program is discussed in Section (1) and the F,E&D in Section (2) .

(1) Aircraft and Related Equipment - F&E.

a. Facilities Flight Inspection. A major function of the FAA aircraft fleet is certifying the performance of air navigation aids and instrument flight procedures supported by these navigation aids throughout much of the world.

b. Flight Training. Flight training is needed for flight inspectors and electronic technicians to acquire and maintain the skills necessary for the flight inspection program.

c. Research Support. FAA aircraft are used to support the FAA engineering and development program by testing new electronic aids, air traffic procedures, aircraft safety improvements, and communications and guidance equipments. Test bed aircraft are configured for rapid installation and removal of equipment being tested, and are equipped with specialized antennas, electrical power, and a variety of test equipment.

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In the latter part of the 1980's it is anticipated that the older inefficient aircraft will be replaced with modern fuel efficient aircraft.

Major elements for the 1987-1991 period include:

Re-engine of eight Sabreliners

Replace Flight Inspection System

Microwave Landing System (aircraft)

Replace five Jet Commander aircraft

Replace 2 Gulfstream aircraft

ATARS

The F&E costs (1980 dollars) of these programs are estimated to total:

FY 1982-1986	$ 75 M
FY 1987-1991	$ 120 M

(2) Aircraft and Related Equipment - F,E&D.

a. Logistics. Aircraft support is required in Alaska to supply remote islands and areas with priority transportation and emergency rescue services; and in the contiguous U.S., support is required for the emergency transportation of aircraft engines and aircraft maintenance crews.

b. Flight Training. Training is necessary to enable FAA air carrier and general aviation inspectors to provide quality and standardization in issuing airman certificates and conducting surveillance checks of air carrier operations. Nonflight inspection aircraft and avionics are planned to be provided, improved or replaced to keep inspectors current in the latest technology and to maintain proficiency in their duties.

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The F,E&D costs (1980 dollars) of these programs are estimated to total:

FY 1982-86	$ 25 M
FY 1987-91	$ 16 M

F. RESEARCH AND DEVELOPMENT. Included in this section is a brief description of R,E&D programs in support of the F&E ten year plan and the R,E&D programs not scheduled for implementation until after 1991. Those programs supporting the ten year plan (implementation prior to 1991) are described more fully in the En Route, Terminal, Flight Services and Technical Support sections of this chapter. Also, a complete description of program activities, major milestones and fiscal planning are contained in Appendices II and III, "Research, Engineering and Development."

(1) 01 1/ Systems Program. This program provides the overall systems engineering and guidance needed to plan and integrate efforts to progressively upgrade the National Airspace System. The scope of this program includes evaluation of the current ATC system performance; the determination of future performance requirements; the development of long-range research programs, requirements studies, and cost/benefit analyses; and the identification of potentially needed system changes.

The costs of this program are estimated to total:

	FY-80 Dollars	Current Year Dollars
FY 1982-86	$ 98 M	$ 135 M
FY 1987-91	$ 148 M	$ 294 M

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(6) <u>06 Communications.</u> The R,E&D objective is to develop a communications system for the transmission of voice and the distribution of data rapidly, accurately, reliably and economically in support of the future highly Automated air traffic control system. The objective includes both air-ground and ground-ground voice and data communication.

The costs of this program are estimated to total :

	FY-80 Dollars	Current Year Dollars
- FY 1982-86	$ 57 M	$ 75 M
- FY 1987-91	$ 57 M	$ 110 M

(7) <u>07 Approach and Landing Systems.</u> The goal of this program is to develop and support the implementation of the Microwave Landing System (MLS).

Another major program in this development area consists of exploring new ways of increasing crew performance and reducing collective avionics costs by assessing the impact of new avionics associated with ATC improvements. This effort will also explore the possibilities of improving crew performance by such programs as Heads-Up Displays (HUD's), the display of traffic information in the cockpit (CDTI) and the eventual integration of originally separate avionics.

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The costs of this program are estimated to total:

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FY 1987-91	$ 117 M	$ 225 M

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Consultation with members of the aviation community revealed that they were generally satisfied with the Airport Grants-In-Aid Program, but believed that higher funding levels were needed. This was particularly true in the area of reliever airport development. The grant program had set aside $15 million annually to help develop reliever general aviation airports that could attract light aircraft away from congested air carrier airports. The level of funding proved to be inadequate, and a backlog of requests for Federal aid to reliever airports accumulated. The immediate problem was alleviated by the satellite airport program in fiscal years 1979 and 1980, under which over $100 million in development aid and navaids was directed to these airports. A longer range solution was proposed in the form of the post 1980 primary hub concept, under

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- Terminal Control. Terminal control personnel are employed in Airport Traffic Control Towers (ATCT's) and Terminal Radar Control Facilities (TRACON's and TRACAB's). Their primary responsibility is to ensure the separation of aircraft arriving and departing airports over which the terminal facilities have jurisdiction.

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Other. Specialists at the ATC Systems Command Center provide flow control services, military altitude reservations and airport reservations at quota airports. Specialists at the National Flight Data Center operate the Notice to Airmen and aeronautical information services. Specialists at the National Communications Center operate the communication switching systems. Specialists at regional and national headquarters offices provide policy development, directions, supervision and evaluation services.

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g. Airports. In the administration of the airports program, personnel are needed to develop and publish the National Airport System Plan, to administer grants for airport planning and development and to provide engineering, advisory and control services. Airports personnel are further required to develop and enforce the Federal Aviation Regulations relating to airports and ensure that airports which require airport operating certificates meet these regulations.

h. Centralized Training. The FAA operates a centralized training facility at the FAA Academy in Oklahoma City, Oklahoma. It also operates a management training school and a wide variety of other training programs. The personnel associated with these programs are included in this category.

i. Direction, Staff and Support. These personnel provide direct administrative support to the overall FAA mission. They provide executive direction and management and administrative support including personnel, budget, accounting, planning, etc. These personnel also develop preparedness plans and direct preparedness programs to assure effective support of civil and military aviation in a national emergency.

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FIGURE IV-4

Personnel Requirements

(Full Time Permanent Positions)

Positions	FY-1981 Allocation	Planned FY-1986 Requirements	Planned FY-1991 Requirements
A. OPERATIONS			
Air Traffic	30,298	31,298	32,548
Airway Facilities 1/	12,677	11,584	11,330
Installation & Materiel	2,030	2,005	2,005
Aviation Standards	4,639	4,526	4,526
Medical	282	290	290
Development Direction	174	171	171
Airports	559	572	572
Centralized Training	1,032	980	980
Civil Aviation Security	284	272	272
Direction, Staff and Support	2,357	2,315	2,315
TOTAL OPERATIONS	54,332	54,013	55,009
B. FACILITIES, ENGINEERING AND DEVELOPMENT	151	151	151
C. RESEARCH, ENGINEERING AND DEVELOPMENT	769	769	769
D. FACILITIES AND EQUIPMENT	1,332	1,332	1,332
E. OPERATION AND MAINTENANCE, METROPOLITAN WASHINGTON AIRPORTS	826	826	826
F. AVIATION INSURANCE	2	2	2
TOTAL POSITIONS	57,412	57,093	58,089

1/ Airway Facilities includes the following:

	1981	1986	1991
- Field Maintenance	11,502	10,414	10,160
- Program Maintenance and Evaluation	1,175	1,170	1,170
TOTAL	12,677	11,584	11,330

FIGURE IV-4
Personnel Requirements
(Full Time Permanent Positions)

Positions	FY-1981 Allocation	Planned FY-1986 Requirements	Planned FY-1991 Requirements
A. OPERATIONS			
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Direction, Staff and Support	2,357	2,315	2,315
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TOTAL	12,677	11,584	11,330

GA	General Aviation
GPS	Global Positioning System
HUD	Head-Up Display
IFM	Integrated Flow Management
IFR	Instrument Flight Rule
ILS	Instrument Landing System
LLWSAS	Low Level Wind Shear Alert System
MLS	Microwave Landing System
MSAW	Minimum Safe Altitude Warning
MTD	Moving Target Detector
NADIN	National Airspace Data Interchange Network
NAS	National Airspace System
NASP	National Airport System Plan
NEXRAD	Next Generation Weather Radar
RCAG	Remote Center Air-Ground Communications Facility
R&D	Research and Development
R,E&D	Research, Engineering and Development
RMM	Remote Maintenance Monitoring
RVR	Runway Visual Range
SAM	System Acquisition Management Process
STOL	Short Take-Off and Landing
TAGS	Terminal Automated Ground Surveillance System
TCA	Terminal Control Area
TIDS	Terminal Information Display System
TRACAB	Terminal Radar Approach Control in Tower Cab
TRACON	Terminal Radar Approach Control
TRSA	Terminal Radar Service Area
VASI	Visual Approach Slope Indicator
VFR	Visual Flight Rule
VOR	Very High Frequency &&directional Range
VORTAC	Very High Frequency Omnidirectional Range (VOR) and Tactical Air Navigation (TACAN)
VSCS	Voice Switching and Control System
WMSC	Weather Message Switching Center
WVAS	Wake Vortex Avoidance System

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WMSC	Weather Message Switching Center
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	FY 1982	FY 1983	FY 1984	FY 1985	FY 1986	TOTAL FY 1982-1986	TOTAL FY 1987-1991
b. Automation Equipment (Continued)							
En Route Flight Data Systems	11.0					11.0	
Automation Improvements/Enhancements		9.0		3.0		12.0	27
Oceanic Automation and Display System		2.0	4.0			6.0	
-Establish Radar Training Facilities at ARTCCs			15.0	7.5	7.5	30.0	
En Route Computer Replacement					393.0	393.0	914
c. Other Center Facilities							
Enhance National Airspace Data Interchange Network (NADIN)	5.1	10.0	3.0	3.8	19.7	41.6	
Establish Remote Center Air/Ground (RCAG) Facility Channels	2.2	2.0	2.0	2.0	2.0	10.2	14
Modernize/Improve Sectorization	1.2	1.7	1.7	1.7	1.7	8.0	9
RCAG Signal Control Equipment-Replacement	3.8	19.0	20.0	7.0		49.8	
Establish Plan View Displays (PVDs)		14.0				14.0	
System Replacement Other Vacuum Tube Amplifiers (ARTCC)		4.0	1.5	2.0	2.0	9.5	
Replace/Improve Communications		1.6	1.5	2.0	2.0	7.1	12
Center Building/Plant Modernization		.8	1.6	1.6		4.0	
Enroute VSCS							90

	FY 1982	FY 1983	FY 1984	FY 1985	FY 1986	TOTAL FY 1982-1986	TOTAL FY 1987-1991
b. Automation Equipment (Continued)							
En Route Flight Data Systems	11.0					11.0	
Automation Improvements/Enhancements		9.0		3.0		12.0	27
Oceanic Automation and Display System		2.0	4.0			6.0	
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Center Building/Plant Modernization		.8	1.6	1.6		4.0	
Enroute VSCS							90

	FY 1982	FY 1983	FY 1984	FY 1985	FY 1986	TOTAL FY 1982-1986	TOTAL FY 1987-1991
b. Terminal Area Automation (Continued)							
Terminal Backup Display System							14
Digital Remoting - Satellite ATCT							33
Terminal Computer Replacement							598
Terminal Automated Ground Control System							20
Automated Airport Advisory System							75
Replace/Provide Flight Data Entry and Printout System (FDEP) with FDIO	$3.9	$3.2				$7.1	
Expand Enhanced Target Generator (ETG) Labs			6.0	6.0	6.0	18.0	
c. Other Tower Facilities							
Establish Airport Traffic Control Tower (ATCT)	1.5	10.6	2.8	2.8	2.8	20.5	25
Relocate ATCT	33.6	50.0	60.0	50.0	60.0	253.6	250
Modernize ATCT		10.0	10.0	10.0	10.0	40.0	57
Replace Communication Equipment	11.9	17.0	24.9	10.1		63.9	
Remote Maintenance Monitors		10.0	15.0	15.0	15.0	55.0	370
Voice Switching and Control System			15.0	15.0		30.0	170
Replace Recorders			15.0	10.0		25.0	92
Power Conditioning System-Automated Radar Terminal System III (ARTS III)			7.0	7.0	7.0	21.0	
Automated Weather Observation Equipment	4.0	1.0	1.0	15.0	15.0	36.0	58

	FY 1982	FY 1983	FY 1984	FY 1985	FY 1986	TOTAL FY 1982-1986	TOTAL FY 1987-1991
b. Terminal Area Automation (Continued)							
Terminal Backup Display System							14
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Establish Airport Traffic Control Tower (ATCT)	1.5	10.6	2.8	2.8	2.8	20.5	25
Relocate ATCT	33.6	50.0	60.0	50.0	60.0	253.6	250
Modernize ATCT		10.0	10.0	10.0	10.0	40.0	57
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	FY 1982	FY 1983	FY 1984	FY 1985	FY 1986	TOTAL FY 1982-1986	TOTAL FY 1987-1991
c. Instrument and Visual Landing Systems (Continued)							
Establish/Upgrade Runway Visual Range (RVR) Equipment	$1.9	$2.0	$2.2	$2.3	$2.4	$10.8	29
Establish/Convert Runway End Identification Lights (REIL)	.8	1.3	2.0	2.0	1.0	7.1	20
Establish Visual Approach Slope Indicators (VASI)	1.0	2.6	3.6	3.6	3.6	14.4	21
Improve Navigation/Landing Aids	3.4	1.8	1.0	1.0		7.2	9
d. Housing, Utilities, and Miscellaneous Facilities							
Utilities and Miscellaneous							
Acquire Land	3.4	3.4	3.4	3.4	3.4	17.0	47
Local Projects/Teletypewriter Relocates/ Emergency Restorations	2.7	2.0	2.0	2.0	2.0	10.7	14
Replace/Improve/Relocate Modernize Miscellaneous Facilities/Equipment	2.0	2.0	2.0	2.0	2.0	10.0	33
In-Service Engineering	10.2	10.0	10.0	10.0	10.0	50.2	72
Provide Uninterrupted Power Transfer	1.1					1.1	
Establish Tramway	2.0					2.0	
Modernize Unmanned Facilities		4.5	5.3	5.6	3.8	19.2	
Provide Energy Improvements			4.0	4.0	4.0	12.0	22

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CO

APPENDIX II

Research, Engineering and Development Program Descriptions For The Period

FY 1982 - 1991

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Research, Engineering and Development Program Descriptions For The Period

FY 1982 - 1991

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FY 1982 - 1991

will provide major increases in controller productivity and will permit a higher level of flexibility of aircraft operations than the current system permits. The data processing system will perform routine tasks involved in generation of clearances and resolution of conflicts, allowing the controller to devote this attention to exception handling, emergency situations, and ATC system management duties.

It is expected that the automated planning and control system -- an extremely difficult technology problem -- would enter full operational service after the computer replacement program is well along (in the 1990-2000 time frame) . The system will be modular and will probably begin by providing tools to permit controllers to better visualize complex traffic situations and to permit adaptive airspace utilization with adaptive rules. It is expected that this system will build upon elements of the Integrated Flow Management Program.

Other advanced concepts to be explored and developed are:

- Automated Mixed Profile - Determining the most efficient utilization of runway and approach configuration to accommodate an extreme mixture of aircraft types such as general aviation, wide body jets, STOL aircraft and helicopters.

- Electronic Flight Rules (EFR) - Develop a new concept whereby a certain level of protection might be achieved by participating aircraft without requiring full participation in the ATC system.

- Cockpit Display of Traffic Information (CDTI) - An effort to explore the capabilities and limitations of CDTI systems for EFR functions as well as for other functions.

- Satellite System Exploration - An effort to explore the beneficial applications of satellite technology to oceanic applications. A result of this study will address the requirements for potential satellite utilization for domestic communications and ATC surveillance.

- Computer Aided Reasoning (Artificial Intelligence) - An effort to expand the latest scientific exploration of melding the human thought processes to computer technology so that computers can be built with the capability to reason and to learn. Specific applications are for both aircraft cockpits and in the ATC system to permit optimum interaction between man and machine.

FISCAL PLAN

FY 82-86	FY 87-91
134,852	293,608

will provide major increases in controller productivity and will permit a higher level of flexibility of aircraft operations than the current system permits. The data processing system will perform routine tasks involved in generation of clearances and resolution of conflicts, allowing the controller to devote this attention to exception handling, emergency situations, and ATC system management duties.

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FISCAL PLAN

FY 82-86	FY 87-91
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Improved beacon (secondary radar) surveillance capability to reduce problems associated with the existing ATCRBS system and to provide improved surveillance accuracy.
Improved aircraft separation assurance services.
Traffic information for safe operations into uncontrolled airports that do not have manned control towers but are in need of ATC services.

FY 1982-86 Support of F&E 10 Year Plan

A major part of the effort needed to realize the first three of the above goals will be based on the development, test and preparation of procurement data for the Discrete Address Beacon System (DABS) and the colocated and integrated Automatic Traffic Advisory and Resolution Services (ATARS) . Follow on activities during FY 1982-86 will include :

The development of a version of DABS specifically suited for remotely located, unmanned en route surveillance sites. Special emphasis will be given to remote maintenance monitoring, and high reliability to assure operations without scheduled maintenance for long periods of time.
ATARS developmental efforts will continue through the period to improve the original alogrithms and to provide new capabilities.
Methods, procedures and tools will be developed to assist in site adaptation and operational evaluations.

FY 1986-91 R,E&D Program

Major activities during this time period will include feasibility studies and development programs for:

Support ATARS testing, evaluation and implementation.
Enhanced ATARS development.
Automated Traffic Advisory System, beacon based (ATS)

FISCAL PLAN

FY 82-86	FY 87-91
34,543	64,841

4. PROGRAM 04 - NAVIGATION

OBJECTIVES/GOALS: FAA's navigation program is to enhance aircraft navigational safety, improve en route/terminal capacity efficiency, and improve cost-effectiveness of near-term and future navigation services.

FY 1982-86 Support of F&E 10 Year Plan

Support development, test and analysis of near-term air navigation systems/services.

Improved beacon (secondary radar) surveillance capability to reduce problems associated with the existing ATCRBS system and to provide improved surveillance accuracy.
Improved aircraft separation assurance services.
Traffic information for safe operations into uncontrolled airports that do not have manned control towers but are in need of ATC services.

FY 1982-86 Support of F&E 10 Year Plan

A major part of the effort needed to realize the first three of the above goals will be based on the development, test and preparation of procurement data for the Discrete Address Beacon System (DABS) and the colocated and integrated Automatic Traffic Advisory and Resolution Services (ATARS) . Follow on activities during FY 1982-86 wi ll include :

The development of a version of DABS specifically suited for remotely located, unmanned en route surveillance sites. Special emphasis will be given to remote maintenance monitoring, and high reliability to assure operations without scheduled maintenance for long periods of time.
ATARS developmental efforts will continue through the period to improve the original alogrithms and to provide new capabilities. Methods, procedures and tools will be developed to assist in site adaptation and operational evaluations.

FY 1986-91 R,E&D Program

Major activities during this time period will include feasibility studies and development programs for:

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OBJECTIVES/GOALS: FAA's navigation program is to enhance aircraft navigational safety, improve en route/terminal capacity efficiency, and improve cost-effectiveness of near-term and future navigation services.

FY 1982-86 Support of F&E 10 Year Plan

Support development, test and analysis of near-term air navigation systems/services.

FISCAL PLAN

FY 82-86	FY 87-91
24,900	31,452

6. PROGRAM 06 - COMMUNICATIONS

OBJECTIVES/GOALS: Develop a communication system for the transmission and distribution of voice and data rapidly, accurately, reliably and economically in support of the future highly automated air traffic control system. The objective includes both air-ground and ground-ground voice and data communications.

FY 1982-86 Support of F&E 10 Year Plan

Replacement of the air-ground and ground-ground voice communication system with an integrated modern voice communication system. Specific installation requirements for FSS, tone channeling equipment replacement, ATCT and en route centers will be developed.

Data communications improvements include enhancements to NADIN to support FSS Automation, flight data input/output (FDIO) implementation and support for remote maintenance monitoring.

FY 1987-91 R,E&D Programs

Principal programs during this time frame include:

NADIN Enhancements
Support the data requirements for the ATC computer replacement program.
Support the utilization of DADS Data Link to improve ground-air-ground communications and data transfer.
Support the distribution of hazardous weather information to pilots and controllers (including NEXRAD data requirements).
Support the communications requirements of other DOT model agencies, e.g., Coast Guard, NHTSA.
Integration of voice and data communications networks.

FISCAL, PLAN

FY 82-86	FY 87-91
75,131	109,673

FISCAL PLAN

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FISCAL, PLAN

FY 82-86	FY 87-91
75,131	109,673

FISCAL PLAN

FY 82-86	FY 87-91
31,932	60,259

8. PROGRAM 08 - AIRPORTS

OBJECTIVES/GOALS: Improve airport capacity, safety and efficiency to meet future traffic increases.

FY 1982-86 Support of F&E and ADAP 10 Year Plan

Development of airport safety improvements including new lighting configurations, visual aids, skid resistant pavements and crash-f ire-rescue equipment.

Develop cost-effective design guidelines, construction techniques, maintenance procedures and new materials, and reduced construction methods for runway strengthening.

Development of guidelines for providing for accommodations in airport terminal buildings for elderly and handicapped persons.

Study energy efficient installations for runway and approach lighting and other airport facilities.

Increased airport capacity through minimization of the aircraft trailing wake vortex effect in the terminal airspace. Testing and evaluating pavements to determine useful life and provide cost effective rehabilitation alternatives. Although some systems are presently available they are time consuming and require substantial runway downtime.

Developing better methods for designing pavements in a freeze-thaw environment, the techniques of recycling, rubber removal and design for substantial higher traffic flows.

Assistance for Elderly and Handicapped Travelers.

FY 1987-91 R,E&D Programs

Long-range programs include developing visual guidance systems for helicopter and STOL operations under varying IFR weather conditions.

Major research will continue on improving the skid resistant characteristics of pavements new concepts such as a "percussive" groove and evaluation new surface texturing applications will be considered.

New cost-efficient systems to provide dry or ice and snow free pavements will be analyzed. Such a project would consider new types of removal equipment, surface and subsurface drainage and pavement heating elements.

Research directed toward improving CFR equipment response time through improvements to hardware and aircraft disaster/emergency planning guidelines will be initiated as a long-range effort.

Longer term pavement work will include the development, test and evaluation of new pavement technology.

Investigate the feasibility of ground-based wake vortex avoidance/advisory systems and aerodynamic alleviation, and develop an active tracker to assess strength and movement of wake vortices, and evaluate the potential hazard.

FISCAL PLAN

FY 82-86	FY 87-91
37,540	59,082

9. PROGRAM 09 - AIRPORT/LANDSIDE

OBJECTIVES/GOALS: Reduce negative impact of landside restrictions and identify potential solutions to airport ground access problems.

FY 1982-86 Support of F&E 10 Year Plan

This program addresses the major factors in landside restrictions, the development of practical measures of landside capacity and, after analysis, recommendation of improvement measures to the aviation community.

FISCAL PLAN

FY 82-86	FY 87-91
5,121	9,847

10. PROGRAM 11 - CENTRAL FLOW CONTROL

OBJECTIVES/GOALS: This provides the engineering and development support to upgrade the Central Flow Control Automation System. The major goals are to improve the efficiency of national airspace system management and to reduce aircraft fuel consumption caused by airborne delays due to severe weather and unanticipated system overloads.

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FY 1987-91 R,E&D Programs

During the FY 1986-91 time period the en route R,E&D programs will focus on two major goals:

Higher levels of automated assistance to the controller.
Improved flow management in en route airspace and into terminals.

The experimental Automated En Route ATC (AERA) facility has demonstrated the feasibility of automatically operating conflict free clearances for 10 to 20 minutes into the future. The AERA concept will be progressively expanded in functional capability with discrete implementable packages becoming available during the late 1980's. The AERA concept includes automated planning and coordination for direct route flights, control message automation (CMA) which will interface en route control positions with data link, greater productivity per controller by converting routine tasks to computer processes, and fewer traffic control errors.

Traffic flow management for en route ATC includes features such as determination of optimum fuel paths and profiles and advanced en route metering.

FISCAL PLAN

FY 82-86	FY 87-91
131,055	145,696

12. PROGRAM 13- FLIGHT SERVICE AUTOMATION PROGRAM

OBJECTIVES/GOALS: This program is to support the F&E effort to provide automation capability for the present inefficient, maintenance intensive, overloaded manual flight service station facilities while maintaining the required high level of service to meet the ever increasing number of users.

FY 1982-86 Support of F&E 10 Year Plan

By 1986, R&D activities will have brought the FSS modernization program to the point that Model 2 full automation will have been installed and commissioned in about 25 flight service stations. The Model 1, limited automation, equipment which will be operational at improvements. ETABS and En Route Metering, and initial En Route Software for operation with DADS and ATARS will be ready for implementation decisions during the 1980's. Implementation of the computer replacement system is not expected until after completion of the prototype system development in the late 1980's.

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FY 1981-86 Support of F&E 10 Year Plan

ARTS III enhancements (beacon tracking, conflict alert, and minimum safe altitude warning).
Terminal Information Display System (TIDS) for more efficient flight data handling and consolidation of displays associated with the status of airport communications, navigation and surveillance facilities.
Terminal ATC computer replacement (which will be tailored after the en route ATC computer replacement).
Full Digital ARTS Display (FDAD) for ARTS II and III.
Tower Automated Ground Surveillance System (TAGS) to provide alpha numeric tags for airport surface displays in tower cabs as well as intersection conflict alerting.
Airport Surface Detection Equipment (ASDE) which will provide radar surveillance of all ground traffic at high density airports for use in adverse weather conditions.

Implementation Dates

Implementation decisions are pending for the major products recently completed; namely, ASDE-3, the radar remoting capability with tower cab digital displays evaluated at Tampa-Sarasota, and the visual confirmation system for voice take-off clearance. Technical data packages for the Terminal Information Display System and Full-Digital ARTS Displays will be available for implementation decisions in FY-1982. Implementation decisions on the other programs will be made after project completion in later years.

FY 1987-91 R,E&D Programs

The principal goals that will focus the R,E&D effort during the FY 1986-91 time period include the development of technical data packages (TDP's) for an all digital ARTS II and ARTS III and the development of the advanced terminal sequencing and spacing software which will be operable in a multiple active runway environment and be interfaced with the Wave Vortex Advisory System and advanced en route metering.

A major goal for this time period will be to develop a computer system suitable for replacing the ARTS II and ARTS III computer hardware and software.

A major project of this program is Integrated Traffic Flow Management (IFM). This effort is intended to draw together in an integrated fashion a variety of systems and tools to permit aircraft to operate at their own highest level of efficiency, while maintaining safe and efficient system wide operation and making best use of airway and airport system resources. It will be an integration of aircraft systems, the National Central Flow Control System, en route metering, terminal flow planning and control aids, sensors and systems to allow best use of the airport and runway resources. While accommodating the expanded use of flight management computers incorporating 3D and 4D RNAV capability. This will allow all equipped participants to use optimum fuel utilization flight paths.

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Upgrade the capability of signature recognition of convective turbulence, wind shear and other hazardous weather conditions through improved processing of the output doppler radar sensors.
Define the CWSU interfaces with both the en route and terminal ATC replacement automation systems.
Continue the effort to more effectively detect clear air (CAT) and convective turbulence by airborne sensors.

FISCAL PLAN

FY 82-86	FY 87-91
60,038	126,520

15. PROGRAM 16 - TECHNOLOGY

OBJECTIVES/GOALS: Evaluate the capabilities and applications of technological advancements to the present and future National Airspace System, especially in the areas of advanced data processing and displays, sensor development and applications, computing, and human factors engineering.

FY 1982-86 Support of F&E 10 Year Plan

The technology program is designed to provide the latest state-of-the-art technology to system development. Included in this portion of the effort is advanced system modeling, workload determinates, and techniques to evaluate advanced hardware and software for applications in replacing present computers and automatic sensing equipment.

FY 1987-91 R,E&D Programs

Specific technological advances will be examined for applications of advanced LSI development and applications to avionics equipment, low cost avionics for GA applications and for LSI applications relating to reducing requirements for final avionics.

FISCAL PLAN

FY 82-86	FY 87-91
324,680	133,466

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FY 1987-91 R,E&D Programs

Apply specialized skills and knowledge of in-house technical staff personnel to identify, analyze and resolve potential problems which would affect overall operations of the ATC system.

Interfaces between current R&D programs and existing field equipments are identified and programs adjusted to insure a smooth transition of programs into the field during the next ten years. Overall support to the various R&D and F&E programs will be provided to insure that:

ATC procedures are developed for helicopter traffic.
Simulation support is provided to interface new developments into the operational mode. This includes software maintenance of the various digital simulation facilities at the FAA Technical Center to insure compatibility with current field facilities.
Continue to identify technical interface requirements for current and future systems.
Conduct controller productivity studies related to proposed ATC system improvements.

FISCAL PLAN

FY 82-86	FY 87-91
11,215	14,769

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RESEARCH, ENGINEERING AND DEVELOPMENT
FINANCIAL PROGRAM ANALYSIS
FY 1982 - 1991
R,E&D APPROPRIATION
($'s IN 000's)

CURRENT YEAR DOLLARS

	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991
1. AIR TRAFFIC CONTROL	82,314	175,911	228,150	253,880	194,127	215,232	234,090	251,008	255,834	278,631
01 SYSTEM	13,924	23,890	21,186	31,104	44,748	43,732	52,326	58,830	67,104	71,616
02 RADAR		1,447	536	515	515	10,290	13,770	19,610	12,582	13,428
03 BEACON	7,905	6,642	5,531	5,275	9,190	10,290	12,852	15,688	12,583	13,428
05 AIRCRAFT SEPARATION ASSURANCE	7,060	6,410	5,460	3,510	2,460	3,430	4,590	4,903	7,339	11,190
06 COMMUNICATIONS	8,430	18,431	25,575	12,570	10,125	21,438	23,868	25,493	20,970	17,904
08 AIRPORT/AIRSIDE	4,245	8,236	6,259	8,100	10,700	10,290	11,016	11,766	12,582	13,428
09 AIRPORT/LANDSIDE	360	695	864	1,354	1,848	1,715	1,836	1,961	2,097	2,238
11 ATC SYSTEMS COMMAND CENTER		399	598	2,916	2,916	3,430	4,590	5,883	8,388	6,714
12 EN ROUTE CONTROL	15,885	18,753	22,793	34,506	39,118	36,015	29,376	21,571	25,164	33,570
13 FLIGHT SERVICE STATIONS	4,210	5,394	4,410	4,860	4,007	6,860	11,016	15,688	16,776	17,904
14 TERMINAL/TOWER CONTROL	10,924	18,222	23,298	29,160	41,018	51,450	51,408	47,064	41,940	33,570
16 TECHNOLOGY	7,216	65,397	109,435	117,580	25,052	13,720	14,688	19,610	25,164	40,284
21 SUPPORT	2,155	1,995	2,205	2,430	2,430	2,572	2,754	2,941	3,145	3,357

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